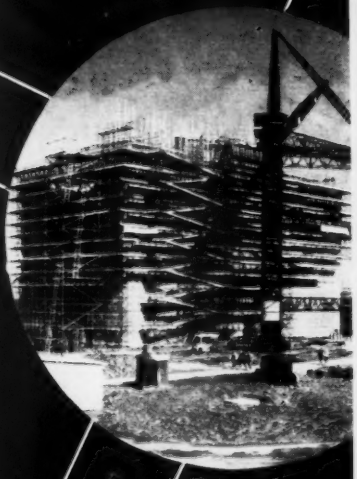
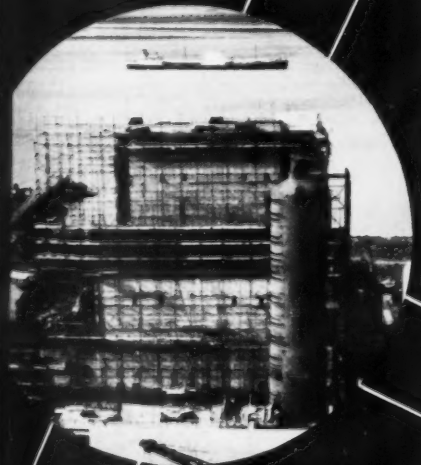
A ROWSE MUIR PUBLICATION

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · RADIATION





Designing a GCR

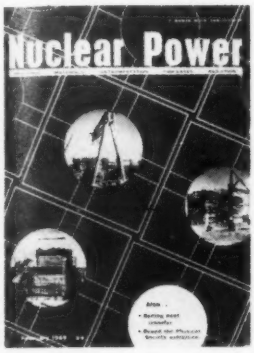
Also . . .

- Boiling in nuclear reactors
- Round the Physical Society exhibition

February 1959 3/6

Tick **No 1** on reply card for further details

VOL 4 NO 34 FEB 1959



Front cover *On a background of the Calder Hall graphite moderator structure, views of some British gas-cooled power stations show progress in construction*

Nuclear Power

REACTORS MATERIALS INSTRUMENTATION PROCESSES · RADIATION

MANAGING DIRECTOR A. H. David Rowse, MA

EDITORIAL

EDITOR Caldwell Davidson, MSC(ENG), DIC
FEATURES EDITOR Patricia May, BSC
NEWS EDITOR John Woodeson, BSC(ENG)
ASSISTANT EDITOR C. E. Steiner
EDITORIAL ASSISTANT Angela Funnell
PRODUCTION MANAGER Gerald Vane, BA (CANTAB)
PRODUCTION ASSISTANT Gerald Withers
CIRCULATION MANAGER Lionel A. Phillips
CIRCULATION ASSISTANT E. A. Hutcheson

CONSULTANTS

INSTRUMENTATION Den's Taylor, PHD, MIEE, FIP
PHYSICS James F. Hill, BSC
METALLURGY Prof J. G. Ball, BSC, FIM
ISOTOPES A. G. Maddock, MA, PHD, DIC

ADVERTISEMENTS

DIRECTOR Harry T. Kane
ADVERTISEMENT MANAGER John Abram
SOUTHERN REPRESENTATIVE K. M. Towell
BIRMINGHAM OFFICE Trevor N. Bertram
MANCHESTER OFFICE Harry C. Aikin
NEWCASTLE OFFICE Peter Doig
CLASSIFIED ADVERTISEMENTS Barry Gibbs

U.S. REPRESENTATIVE

Walter J. Masterson, Jr
Box 206, Essex, Conn. *tel:* South 7-1838

NUCLEAR POWER is published by Rowse Muir Publications Ltd, 3 Percy Street, London, W1, England, and printed by The Haycock Press Ltd, SE5. The entire contents are protected by copyright in Great Britain and all the countries signatory to the Bern Convention; nothing therefrom may be reproduced in any manner without the written permission of Rowse Muir Publications Limited. Nuclear Power must not, without the consent—in writing—from the publishers, be re-sold, lent, hired out or otherwise disposed of in a mutilated condition or in any unauthorized cover, by way of trade, or annexed to or as part of any other publication or advertising, literary or pictorial matter whatsoever. Special attention is called to the fact that your acceptance of this magazine with notice of the above terms constitutes a contract upon these terms between you and the person who sold it or supplied it. Subscriptions to publishers Rowse Muir Publications Ltd. Single copies UK 3/6, 5/6 overseas, 75c US and Canada. Per annum £2.2.0 UK, £3.3.0 overseas, $8.0 US and Canada plus 50s postage.

RM

SPECIAL FEATURES

Designing a gas-cooled reactor
Dr K. J. Wootton of GEC gives a step-by-step description of how a 150 MW project would be tackled 64

Boiling in nuclear reactors
Beginning a two-part article, H. A. Roberts and R. W. Bowring of Harwell deal with present theories of boiling 69

Choosing the right detector
Introducing a new series, A. L. Gray of Plessey Nucleonics reviews basic radiation detection methods 74

Spert-III goes critical
USAEC's latest reactor will be used to investigate power transients in BWRs and PWRs 78

Physical Society Exhibition, 1959
In a quick-reference breakdown, NUCLEAR POWER *reviews this year's most interesting developments* 80

Liquid Metal Fuel Reactor Experiment
Hustace H. Poor of US Babcock and Wilcox gives a progress report on this advanced concept 84

NUCLEAR TECHNOLOGY

REACTORS:
Control rod position indicator *by A. W. Fenton* 85

MATERIALS:
Impermeable graphite *by W. Watt* et al 86

INSTRUMENTATION:
Two ionization chambers for flux scanning *by W. Abson and M. Awcock* 89

PROCESSES:
Determination of boron in carbon dioxide *Chemical Services Dept, Windscale* 88

RADIATION:
Colorimetric analysis of radioactive solutions *by G. P. Kitt and J. H. Moss* 90

PROGRESS IN INDUSTRY

Examining hot specimens
Dounreay mounting and polishing apparatus by Spembly Ltd 92

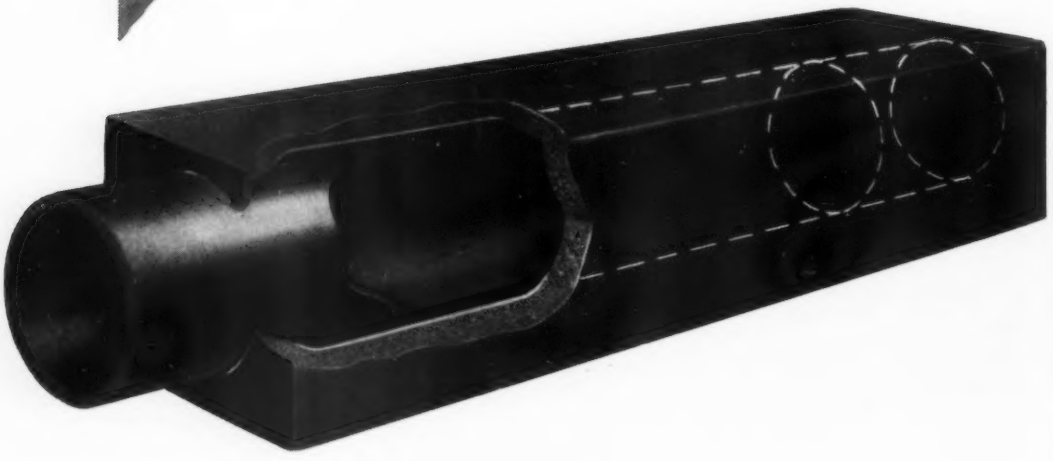
Storing and loading radioactive sources
New facility at Isotope Developments Ltd 93

REGULAR FEATURES

Publisher's Column	51	Names in the News	104
Letters	53, 55	Points from Papers	106
Leader	57	Patents	108
Worldview	59	Diary	110
Cross-Section *Gracchus*	91	Catalogues & Bulletins	110
New Product Survey	94	Book Reviews	112
Industrial Newsdesk	99	Classified Advertisements	137

ROWSE MUIR PUBLICATIONS LTD, 3 PERCY STREET, LONDON, W1, ENGLAND tel: Museum 8252

MACHINING OF NUCLEAR GRAPHITE UNDER CLEAN CONDITIONS



by Powell Duffryn

DELANIUM CARBON & GRAPHITE

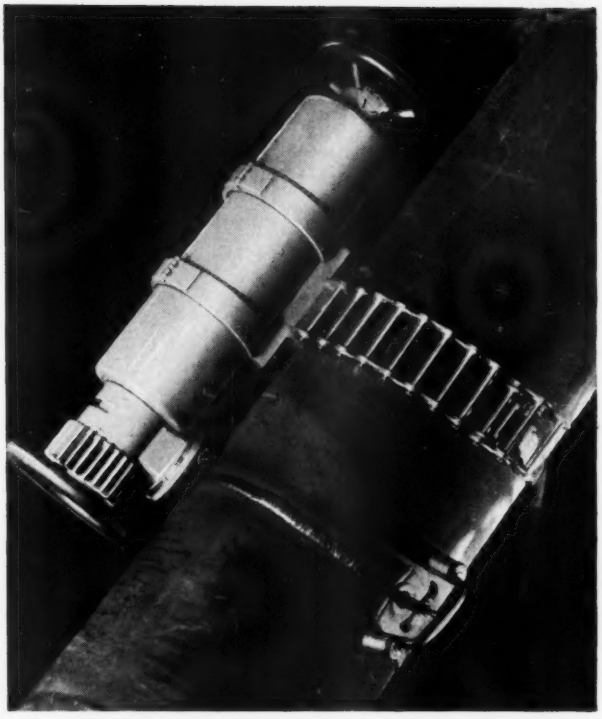
CARBON PRODUCTS LIMITED

SPRINGFIELD ROAD, HAYES, MIDDLESEX TELEPHONE: HAYES 3994

Müller
X-ray equipment

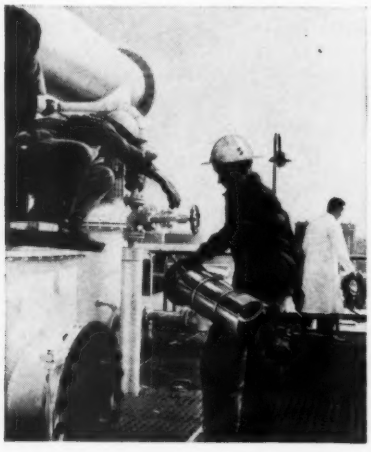
for non-destructive testing

If you are concerned with the type of inspection depicted here, your choice will be the 'Macrotank' . . . available in sizes up to 260 kV

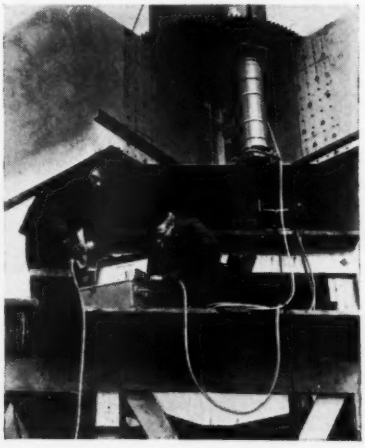


Examining a welded joint in a pipe-line. 'MACROTANK D' supported by adjustable quick-acting clamp. Fine-focus tube (focal-spot size only 1.5 mm!) gives high definition even at short focus-film distances.

Inspecting the tail structure of a large passenger-carrying aircraft. On account of its performance and portability airline operators rate the 'MACROTANK D' very highly. Many famous firms in the aviation industry use Müller equipment.



Weld inspection at an oil refinery. Moving a 'MACROTANK D' to another part of the site. For open-ended vessels, circumferential welds can be radiographed from within; up to 120° with a single exposure or 360° with Model F.



Site welding inspection with the 'MACROTANK H'. This unit has a penetration of 3½" of steel. Tension variable over the range 60-260 kV (stepless). Ideal for shipyard work and bridge construction. Provided with outdoor-type (rainproof) control box.

Write now for fully descriptive literature

Sole Distributors in U.K.:

RESEARCH & CONTROL INSTRUMENTS LTD

Instrument House · 207 King's Cross Road · London · WC1

Telephone: Terminus 8444.

C.H.F. MULLER
AKTIENGESELLSCHAFT
RONTGENWERK
HAMBURG

(RC1.0376A)

Tick **No 3** on reply card for further details

LOW-TENSION A.C. AIR BREAK SWITCHGEAR

by

"One of thirty-six
composite Switchboards which are
being installed in the South of Scotland
Electricity Board's Generating Station at Kincardine."

AIR-CIRCUIT BREAKERS, COPPER CONNECTIONS, AND BUS BARS TESTED IN ACCORDANCE WITH A.S.T.A. 16.

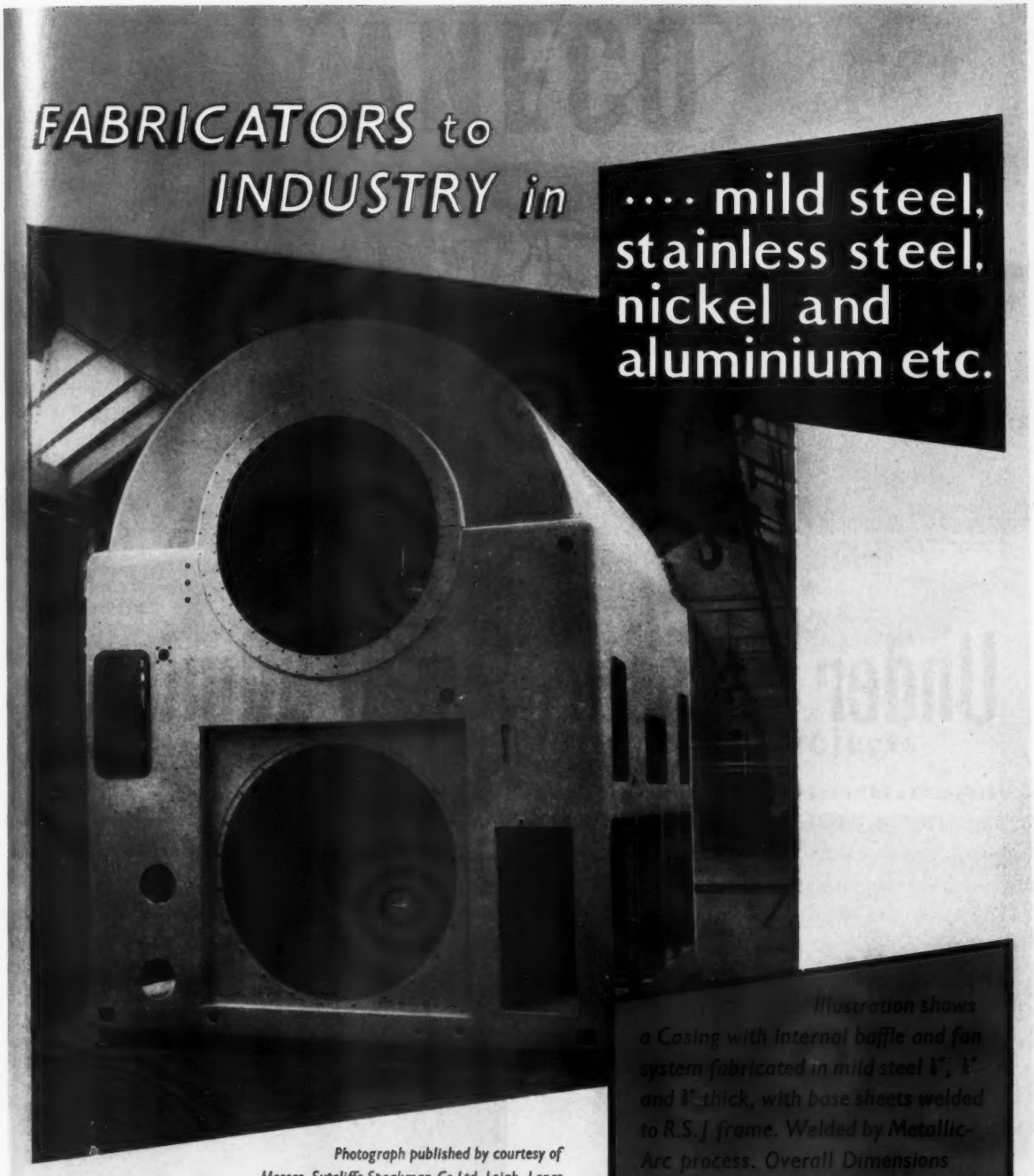
CONSULTING ENGINEERS - MESSRS. KENNEDY & DONKIN

FOR LEAFLET IF/2 WRITE TO

Manufacturers of Air Break Switchgear for the past fifty years

Whipp & Bourne Ltd

SWITCHGEAR WORKS CASTLETON · ROCHDALE · LANCS


FABRICATORS to
INDUSTRY in
···· mild steel,
stainless steel,
nickel and
aluminium etc.
Illustration shows a Casing with internal baffle and fan system fabricated in mild steel ¼", ⅜" and ⅝" thick, with base sheets welded to R.S.J frame. Welded by Metallic-Arc process. Overall Dimensions approx: 12' long x 8' wide x 12' high Weight 7 tons.
Photograph published by courtesy of Messrs. Sutcliffe Speakman Co. Ltd, Leigh, Lancs.

UNIVERSAL BOILERS & ENGINEERING CO. LTD

HEAD OFFICE: FULLEDGE WORKS - BURNLEY - LANCASHIRE - ENGLAND
Telephone 3121/2 and 3203 Burnley (3 Lines) Telegrams: 'UNIVERSAL' Burnley

Associated with BURNLEY AIRCRAFT PRODUCTS LTD. Fulledge Works Burnley Telephone: 3121/2
GROSVENOR STREET, STONEYHOLME, BURNLEY Telephone: 3184
and BRITANNIA WORKS, QUEENSGATE, BURNLEY Telephone: 4102

Under pressure, we'll admit...

... there's quite a lot we know about the behaviour of pipes. Teddington Bellows Expansion Joints are designed and engineered to take up and absorb expansion, contraction and lateral movement of piping in a wide variety of industries.

After Teddington Bellows have been butt-welded from highly finished cold rolled stainless steel sheets, convolutions are introduced to give the bellows their characteristic flexibility under pressure.

Nuclear, chemical, marine and gas engineers acknowledge their efficiency and superiority over many older forms of expansion joints.

Wherever pipe-work is subjected to vibration or movement in any direction, a Teddington Bellows with a suitable end-fitting will solve the problem.

LET OUR ENGINEERS ADVISE ON YOUR EXPANSION PROBLEMS

Send for our brochure No. R 24

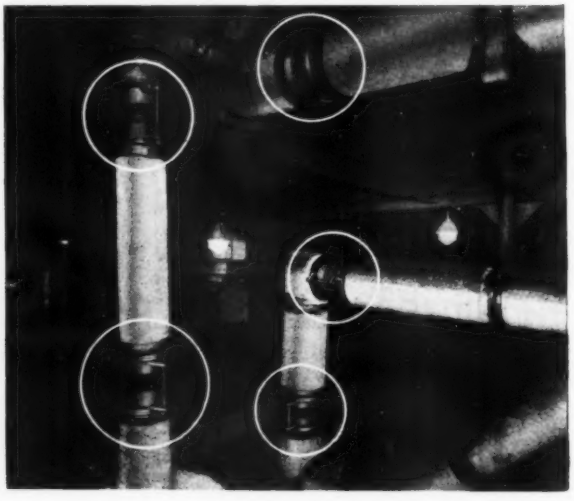
Teddington Bellows are produced in technical collaboration with the Solar Aircraft Co. U.S.A.

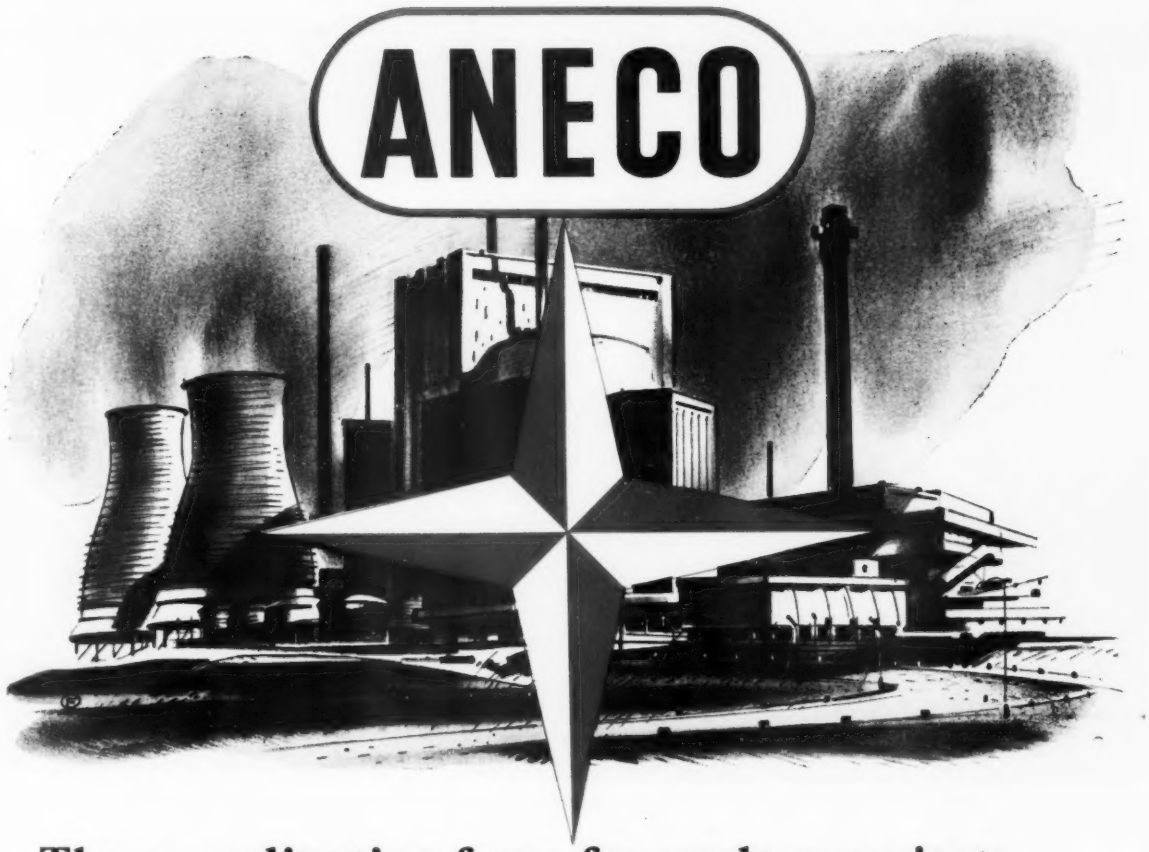
pipes on the move prefer

TEDDINGTON BELLOWS

EXPANSION JOINTS

TEDDINGTON AIRCRAFT CONTROLS LTD
INDUSTRIAL BELLOWS DIVISION
Ammanford, Carmarthenshire. Tel: Ammanford 455



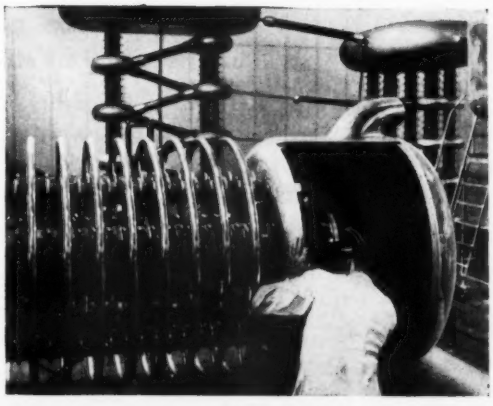


The co-ordinating force for nuclear projects

In a new world of industrial endeavour where ideas may evolve and succeed each other even before prototypes become production units, it can be comforting to know that a centralised organisation exists to advise and channel enquiries for nuclear equipment.

ANECO combines the resources of a group of companies with over seven years experience of varied nuclear projects. Enquiries to ANECO lead to contact with the appropriate production unit within the group, saving time and simplifying procedure in the initial stages for all concerned. ANECO is thus the focal point from which to start; whether you require pilot plant or equipment from fine precision components to 10-ton fabricated units. The majority of the equipment produced by ANECO can be to Harwell specification.

GLOVE AND DRY BOXES	ELECTRONIC EQUIPMENT
ELECTRO-MAGNETS	ELECTRICAL CONTROL DESKS AND PANELS
PRESSURE AND VACUUM VESSELS	LAMINATED PLASTICS
FURNACES	SIGNS, DIAGRAMS AND LABELS
REACTOR COMPONENTS	VACUUM AND FIBREGLASS MOULDINGS
HANDLING TONGS	PRINTED CIRCUITS



Linear Accelerator for A.E.R.E., Harwell.
High intensity 500,000eV injector for 50 million eV proton linear accelerator, delivering pulse beam currents approaching 20mA.

AYLING NUCLEAR EQUIPMENT CO.

Consulting Organisation for

H. & E. LINTOTT LTD. — HAMBLING INDUSTRIES LTD.

BRIBOND LTD.

AYLING INDUSTRIES GROUP

AYLING HOUSE, KINGS ROAD, HORSHAM, SUSSEX. Tel. HORSHAM 3391

Compact and robust construction
Grooves for endwise location
Recirculating steel balls
No loose parts
Retainers keep balls in their tracks

What they are— Designed only for linear motion, **R&M** Ball Bushings contain three or more ingenious ball circuits, round which the balls rotate just as in a conventional ball bearing. Some of these steel balls carry the load in one portion of the circuit whilst the unloaded balls continuously recirculate back to the starting point in a retainer. Each Ball Bushing forms a compact assembly which can be handled as a unit.

What they do— Ball Bushings offer tremendous advantage over plain bearings — all the advantages of effortless rolling as opposed to sliding motion. They reduce starting loads, provide limitless length of stroke and permit higher speeds. Their low co-efficient of friction is hardly affected by changes in load or lubricant viscosity.

Who needs them— Designers — do you specify rolling bearings for rotary motion? Why not use the same advantages for linear motion? **R&M** Ball Bushings bring new potentialities of performance. Their compact design means that they can often replace existing plain bearings.

Their inherent simplicity will bring big economies to your new projects. Operators — Ball Bushings are as easy to fit as a plain bearing. No complicated lubrication systems — no continual maintenance — negligible wear — and yet precision linear motion at all times.

Ball Bushings are brought to you by Ransome & Marles Bearing Company, manufacturers of precision bearings for all types of rotary and linear motion.

NEWS FOR DESIGNERS IN SEARCH OF TRUE LINEAR MOTION

Ransome and Marles Bearing Company bring you a major advance in *linear* motion.

Problems of friction, wear, loss of alignment, chatter and expensive maintenance need be problems no longer. Ball Bushings will give you precision linear motion with savings in cost, weight and power input that you cannot afford to ignore.

Already in nation-wide use in America, Ball Bushings are used in machine tools, aircraft, electronics, office machines, instruments, textile machinery, television, food processing, printing, packaging and general engineering. A full range of Ball Bushings and accessories is now available in this country from our stocks, our manufacturing programme, or direct from the United States. **R&M** Publication 76 gives you full details, facts and figures.

Write or telephone *now* for as many copies as you require.

BALL BUSHINGS BY RANSOME & MARLES

Ransome & Marles Bearing Co. Ltd.
Newark-on-Trent, Notts. Telephone 456 Telex 37-306

Where special conditions need special paints

For resistance against mineral and organic acids, steam, caustic soda, detergents, solvents or abrasion — there is an EVOKOTE paint to give the toughest resistance.

specify **EVOKOTE**

EPIKOTE RESIN BASED PAINTS

A PRODUCT OF EVODE OF STAFFORD

Manufacturers of BITUGEL, EVODYNE and EVO-LED paints

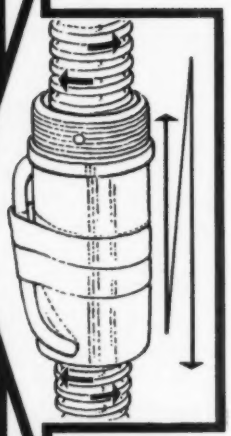
✳ **SEND FOR LITERATURE** *EVODE LTD., (PAINTS DIVISION) STAFFORD. Telephone : 2241-5*

London Office : 82 VICTORIA STREET, S.W.1. Telephone : ABBey 4622-3

M-W.82

the SERCK organisation
PRIMARY AND SECONDARY SURFACE HEAT EXCHANGERS
CONDENSERS
AIR AND GAS COOLERS
CONDENSER TUBES
SERCK RADIATORS LIMITED
SERCK TUBES LIMITED

Armstrong Siddeley provide a comprehensive range of high precision recirculating ball and lead screws and splines for universal applications.



HIGH EFFICIENCY

BACK-LASH ELIMINATION

LONG LIFE

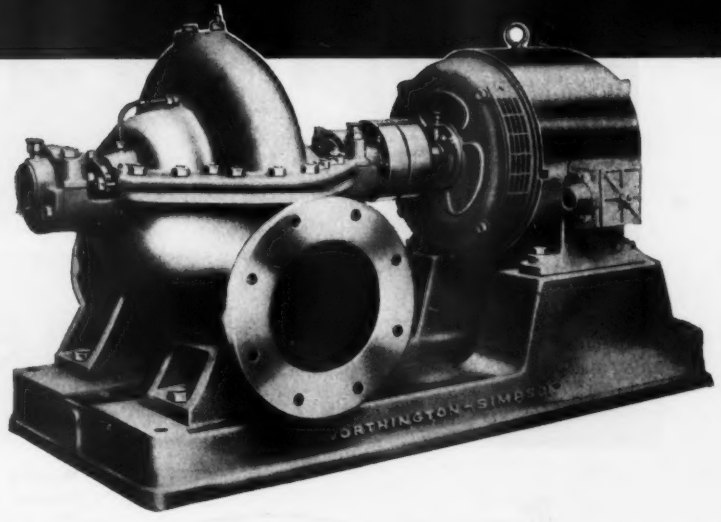
LOW MAINTENANCE FACTOR

Up to 80% reduction in power can be achieved for actuation compared with conventional methods.
Ability to run at high temperatures with and without lubrication.
Over 2,700 applications already established in all fields of engineering.
Complete technical and manufacturing co-operation with Beaver Precision Products Inc., Detroit.

ARMSTRONG SIDDELEY MOTORS
COVENTRY · ENGLAND

MEMBER OF THE HAWKER SIDDELEY GROUP

W/S volute type centrifugal pumps feature split case construction with suction and discharge outlets integral with the lower half casing. This means easy access to the interior for inspection purposes without disturbing shaft alignment or pipe connections. These pumps can be driven by any type of prime mover through any form of transmission. Single and two-stage models are available covering capacities up to 15,000 g.p.m. and heads up to 600 ft.



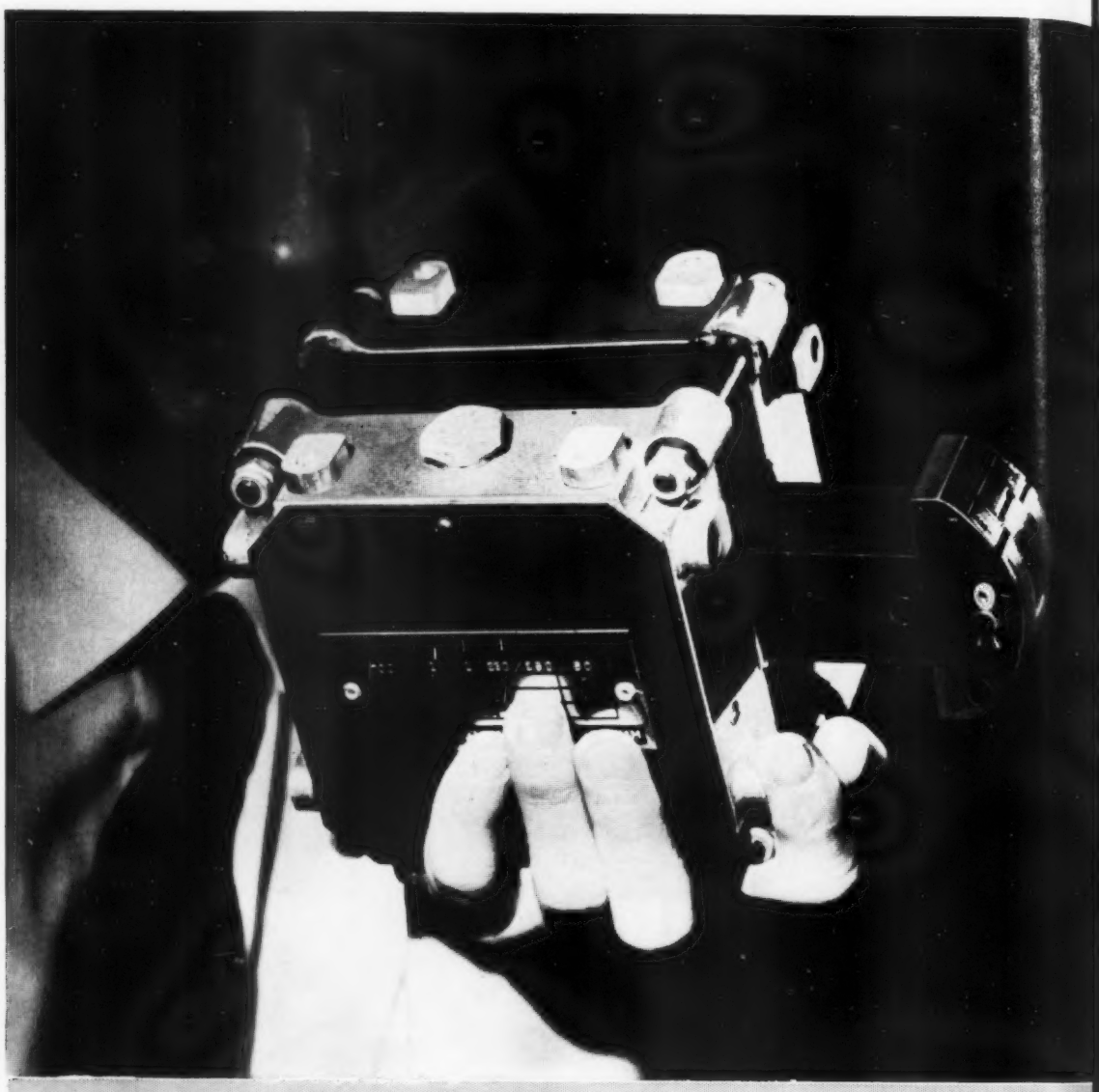
Worthington - Simpson Ltd

PUMPS · COMPRESSORS · HEAT EXCHANGE EQUIPMENT

NEWARK NOTTS

P2367

Tick **No 13** on reply card for further details



WESTOOL SOLENOIDS

Westool Solenoids are 'naturals' wherever automatic control is required. Being electrically operated, they can be incorporated easily into any control system whether fully automatic or push-button; being compact they lend themselves to the streamlined machine layout of today. Their action is instantaneous and certain.

Westool make a wide standard of A.C. and D.C. Solenoids to cover most industrial requirements, and some of these are illustrated here. Practical design, use of the best materials, care in manufacture and thorough testing ensures that Westool Solenoids are the best you can obtain.

For technical data sheets and price list write or telephone today

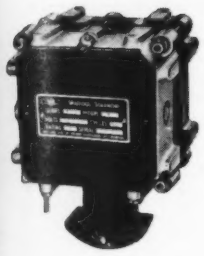
WESTOOL LIMITED

ST. HELEN'S AUCKLAND, CO. DURHAM

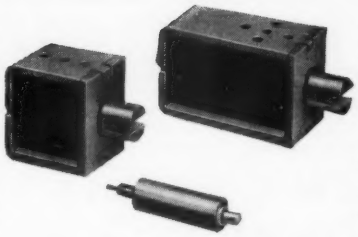
Phone: West Auckland 551/5 **Grams: Solenoid, West Auckland**

Birmingham Office:
7 Newhall St., Birmingham 3
Telephone: Central 3901

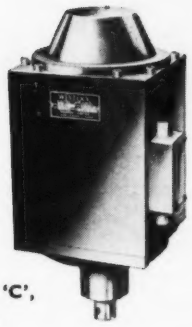
TIB 113



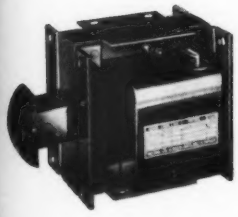
Series 700 A.C.



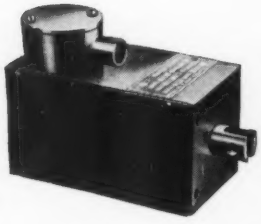
Miniature Solenoids A.C. & D.C. from 225 cm. grammes to 1.5 ozs.



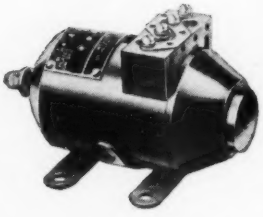
Series 'C', D.C.



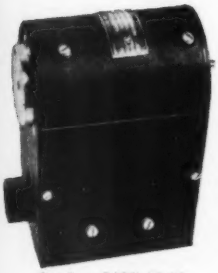
Series 600 A.C.



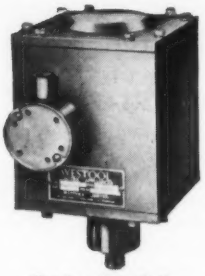
Series 'DK', A.C.



Series 1174 D.C.



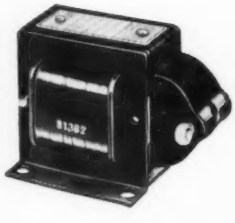
Series 2030 D.C. with rectifier



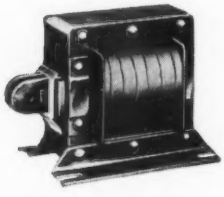
Series 'E', D.C.

Series 'L', D.C.

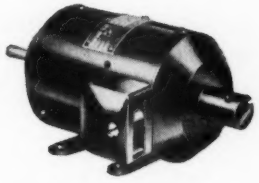
..better designed, better made



Series 500 A.C.



Series 400 A.C.



Series 2030 D.C.

Tick **No 15** on reply card for further details

CONTROL PROBLEMS?

FOR SIMPLE SOLUTION OF YOUR CONTROL PROBLEMS INSTALL THE *Bailey* EI 8 CONTROLLER

INPUTS

THERMO-COUPLES, TELECOILS,

RESISTANCE-ELEMENTS,

OR ANY OTHER SUITABLE SOURCE

APPLICATIONS

FURNACE CONTROL,
PLASTIC EXTRUSION,
TYRE MANUFACTURE,
DYE & SOLDER BATH PROCESSES,
MILK PASTEURISING CONTROL,
IMPREGNATING PROCESSES,
RESIN KETTLE CONTROL

...AND OBTAIN ACCURATE CONTROL AT LOW COST

PRINCIPLE OF OPERATION

A small vane, mounted on the pointer of an 8-inch edgewise indicator, interrupts a light beam directed on to a photo-transistor when the pointer reaches the control set point. This results in operation of large capacity relay contacts. The set point may be varied over the indicated range by adjustment of a front panel control.

Please send for leaflet (E) E51-9

SPECIAL FEATURES

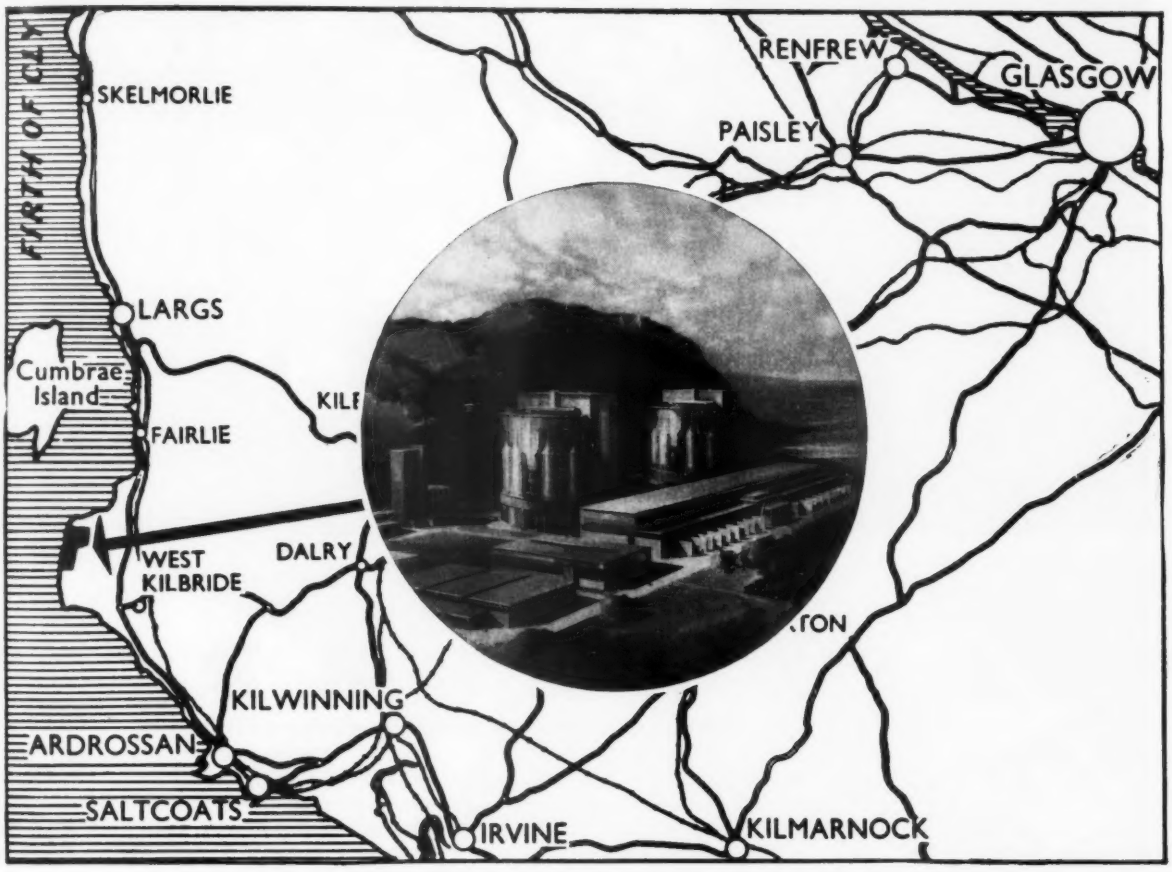
- *Fully transistorised circuit gives utmost reliability*
- *High accuracy and stability*
- *Simple to maintain*
- *All controls on the front pane*
- *Automatic protection against thermo-couple failure*
- *Screwdriver adjustment of thermo-couple lead resistance*

BAILEY METERS & CONTROLS LTD.

PURLEY WAY · CROYDON · SURREY · TEL: CROYDON 4191

INSTRUMENTS AND CONTROL SYSTEMS FOR THE POWER AND PROCESS INDUSTRIES

The Power of the Atom



at Hunterston

Simon-Carves are responsible for nearly half the contract value of the South of Scotland Electricity Board's nuclear power station at Hunterston. This responsibility embraces design and supervision of all civil engineering construction works, including biological shieldings and their cooling systems, all steel structures and building superstructures, the condenser circulating water system and water treatment plants, and the sixteen steam-raising units and auxiliary equipment associated with the two nuclear reactors. At the same time the Simon-Carves research organisation and the international experience of Simon-Carves in heavy engineering design and large-scale contracting are being applied, in association with The General Electric Co Ltd of England, to the development of even more advanced nuclear power stations in Great Britain and throughout the world.

Simon-Carves Ltd

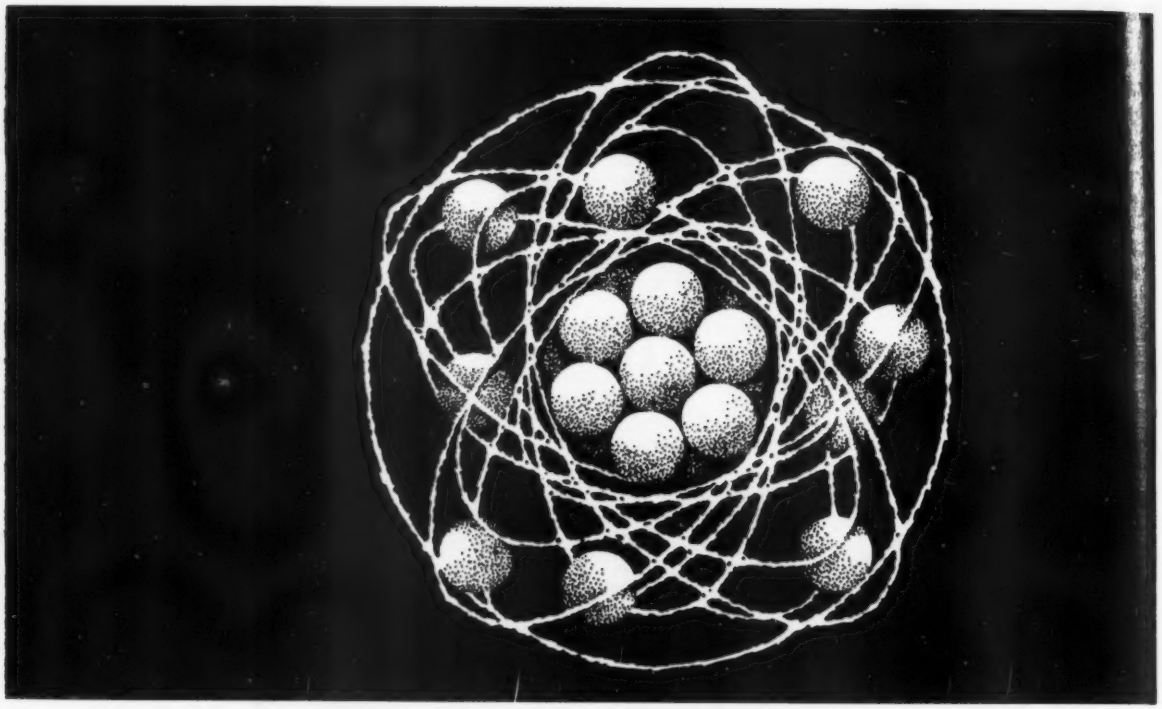
SIMON ENGINEERING GROUP

NUCLEAR POWER DIVISION | Cheadle Heath, Stockport

IN ASSOCIATION WITH THE GENERAL ELECTRIC CO LTD OF ENGLAND

SC202

Tick **No 17** on reply card for further details



Main CO_2 Duct Isolating Valve for Nuclear Reactor Power Plants for working pressures of 10 kg/cm² and 400° C.

E R H A R D

ABSPERRKLAPPEN (Pat. throughout the world)

The design of the ERHARD-Absperrklappen is not limited to the aforementioned temperatures and pressures, and we are in a position to manufacture valves in order to meet the severest temperature and pressure conditions arising in nuclear reactor power plants.

External means are used in order to urge the disc sealing ring on to or away from the valve seat for closing or opening the valve. Operation can be effected according to requirements by hand, electric, pneumatic and hydraulic means.

JOHANNES ERHARD H. WALDENMAIER ERBEN

Süddeutsche Armaturenfabrik Heidenheim an der Brenz Western-Germany

* tailor-made to each job!

MULTIRAIL fabricated steel handrail standards have proved to be as rigid as the solid forged type, with the advantages of four ferrules enabling vacant ferrules to be used in carrying power lines, air and gas pipes, etc.

***MULTIRAIL**
fabricated steel handrail standards

"SAFETREAD" FLOORING IS

welded for extra strength

Tailor-made and not just cut to fit, 'Safetread' flooring is no dearer to specify than ordinary steel flooring, but provides maximum strength with minimum of materials; non-skid surface; 82% light and air penetration; a neat-fitting, clean appearance.

***SAFETREAD**
WELDED FLOORING

Write for detailed literature to:—

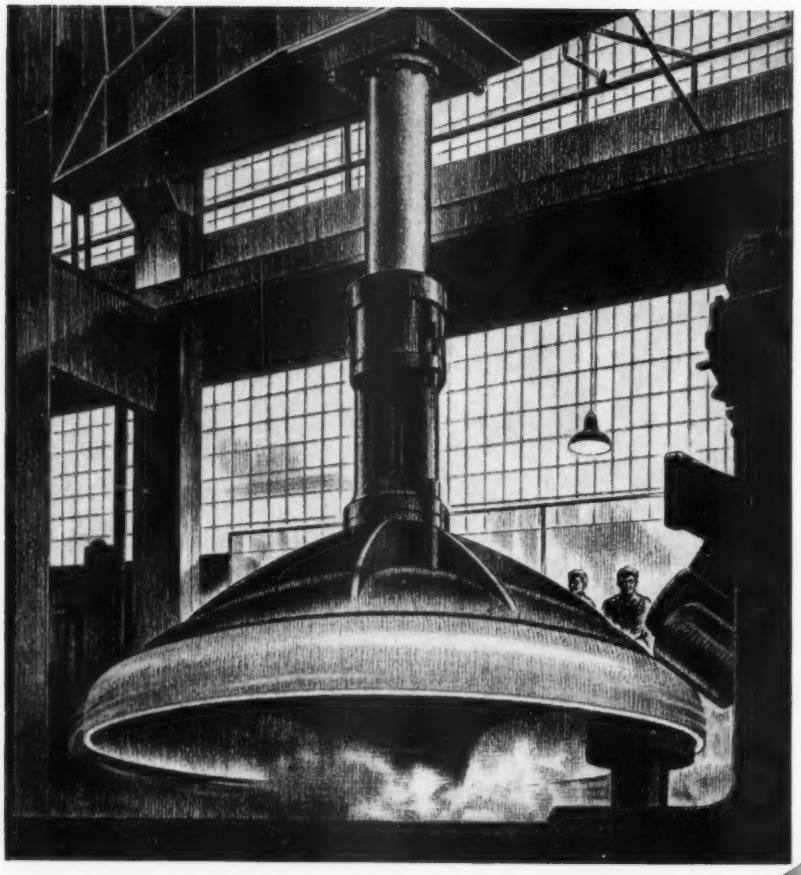
Allan Kennedy & CO. LTD.
MARITIME STREET · STOCKTON-ON-TEES

Tel: Stockton 65464 (4 lines). Grams: Grating, Stockton-on-Tees. Also at 207 Victoria Street, London, S.W.1

Spinning

SAVES METAL

—CUTS TOOL COSTS



The design and production of Pressure Vessels may be greatly facilitated by using dished and flanged ends spun by Harveys on the Rotarpress. They combine semi-ellipsoidal form with large knuckle radius. A substantial reduction in plate thickness can be effected, and in most cases tool costs are eliminated.

'Rotarprest' Ends for Pressure Vessels

can be supplied in Mild, Alloy and Clad Steels and Non-ferrous Metals. The capacity of the Rotarpress ranges from 5 to 15 feet diameter, and $\frac{3}{8}$" to 4" thickness. Knuckle radii and depth may be varied to meet individual requirements.

Please ask for List No. NP 965 giving full range of sizes.

Harvey

G. A. HARVEY & CO. (LONDON) LTD.
WOOLWICH ROAD - LONDON, S.E.7
Telephone: GREenwich 3232 (22 *lines*)

Getting in touch with

ASSOCIATED LEAD

usually leads to better things

No matter how you do it, no matter what your particular industrial need, getting in touch with Associated Lead is bound to lead to better things—better products, better processes—for you and your industry.
Associated Lead Manufacturers Limited is a single company specialising in the manufacture and supply of lead in all its many forms; alloys; pure metals; special chemicals and pigments.

ASSOCIATED LEAD MANUFACTURERS LIMITED CLEMENTS HOUSE, 14 GRESHAM STREET, LONDON, E.C.2.
CRESCENT HOUSE, NEWCASTLE. LEAD WORKS LANE, CHESTER.

Export enquiries to: Associated Lead Manufacturers Export Co. Ltd., Clements House, 14 Gresham Street, London, E.C.2.

Tick **No 21** on reply card for further details

THE MOLLART ENGINEERING CO LTD

designs and manufactures
Special-purpose machine tools and equipment

Fine Boring Machines
Turning Machines
Drilling Machines
Automatic Loading and Unloading Internal Grinders
Simulators
Fine Turning Machines
Turbine Blade Machines
Flow Turning Machines

MOLLART also manufacture

High Precision Equipment of all Types, including Gauges, Tools and Fixtures.
High-Frequency Grinding Spindles up to 90,000 r.p.m.
Special Hydraulic Equipment
Precision Assemblies

Manufacturers of the ℳ universal ball joint for all angular drives

Air Ministry Gauge Test House approved under authority 89755/31

MOLLART ENGINEERING COMPANY LIMITED
KINGSTON-BY-PASS SURBITON SURREY TELEPHONE ELMBRIDGE 0033-7 TELEGRAMS PRECISION SURBITON

For ease of maintenance

Specify

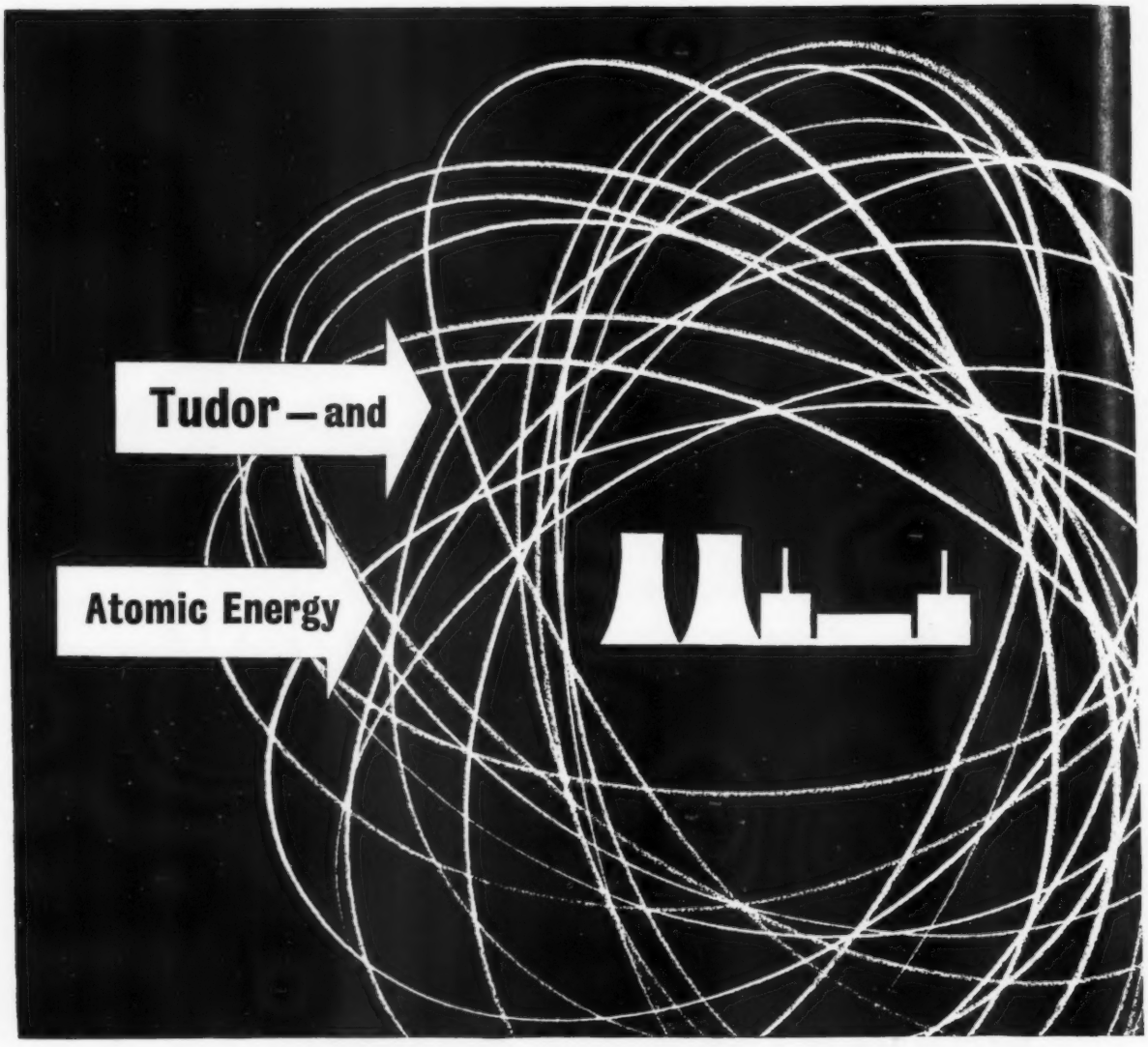
WESTON

SPLIT SEALS

CHARLES WESTON & CO. LTD. Irwell Bank Works · Douglas Green · Pendleton · Salford 6

Telephone: Pendleton 2857-8-9; Telex 66-255; Birmingham Erdington 5459; London Holborn 0414; Telex 2-2682

Tick **No 23** on reply card for further details



Tudor specialize in the design and supply of batteries and allied equipment for atomic energy establishments. Contracts for battery equipment include 240V Station batteries, 110V Switch Closing batteries, 50V Tripping batteries and 50V Control batteries complete with charge and control equipment and distribution boards for each of these Power Stations —

CALDER HALL 'A'
CALDER HALL 'B'
CHAPEL CROSS
DOUNREAY

Supplied under sub-contract from A. Reyrolle & Co. Ltd; The English Electric Co. Ltd; Brush Electrical Engineering Co. Ltd (a member of the Brush Group)

T.159

Tudor BATTERIES

THE D.P. BATTERY COMPANY LTD., BAKEWELL, DERBYSHIRE. TELEPHONE: BAKEWELL 581-5
Works: Dukinfield, Cheshire. Telephone: Ashton-under-Lyne 1651

Rawlbolt charts showing full range of sizes and types with illustrated literature available on receipt of letter-heading or business card.

6 HEADS are better than one!

You never need to improvise with Rawlbolts. There are types exactly right for every bolt-fixing job, No. 5, for example, for the support of pipe-work, and No. 2 for use with Pipe-hangers and other gas fittings. Hook and Eye Rawlbolts (Nos. 3 and 6) have many uses, such as providing anchorage for guy ropes and cables, supporting suspended ceilings, etc. There's the Loose Bolt Rawlbolt (No. 1), inserted after the machine is slid into position, and the Bolt Projecting Type (No. 4), ideal for wall-fixings.

Rawlbolts give you bolt-fixings of enormous strength in a fraction of the time taken by any other method.

1 Loose Bolt Rawlbolt	2 Pipehanger Rawlbolt	3 Eye Rawlbolt
4 Bolt Projecting Rawlbolt	5 Rawlbolt fitted with Pipe Clip	6 Hook Rawlbolt

Every bolt-fixing job is far quicker with

RAWLBOLTS

THE RAWLPLUG CO. LTD., CROMWELL RD., LONDON, S.W.7

B580

AIRMEC INSTRUMENTATION

keeps in step with nucleonic needs

MONITORS

RADIATION MONITOR *Type 1021 B*

★ **SAFEGUARDS against contamination.**

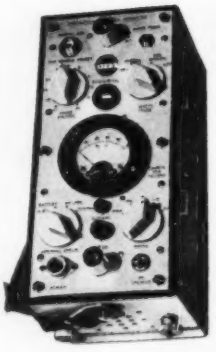
★ **TRACES radio-active material in chemical analytic processes.**

★ **MEASURES contamination of any resulting effluent.**

Designed in conjunction with A.E.R.E. Harwell, this instrument is probably the most widely used general purpose monitor in the world. It has been PROVED by years of user experience to be the most accurate and reliable equipment of its type.

The Radiation Monitor consists of a mains operated Indicator Unit together with a Beta Gamma or Alpha Probe Unit. Indication is provided visually by means of a meter which is calibrated in counts per second, and audibly by means of a loudspeaker. A socket on the front panel is also provided to enable the output to be fed to a scaling unit.

Write for descriptive leaflet No. 26D giving full details.



RADIATION MONITOR *Type 255*

★ **Transistorised, battery operated, portable.**

★ **Laboratory accuracy under field conditions.**

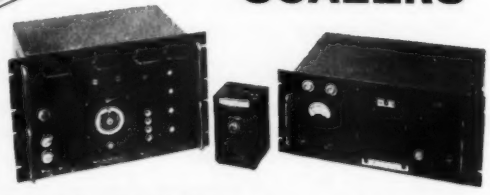
★ **Wide range of probes and accessories available.**

Airmec are proud to be the first to announce a fully transistorised monitor which combines laboratory accuracy with complete portability. The uses include :

1. Checking the presence and amount of radio-active contamination in laboratories and workshops.
2. Checking atmosphere 'fall-out' and contamination of food, animals, crops, milk and water supplies, etc.
3. Following the progress of radio-active tracer elements in medical, geological, agricultural and industrial processes.
4. Tracing the whereabouts of radio-active areas and making accurate assays of samples in geological surveys.
5. Tracing lost samples of radio-active materials both in buildings and out.

Write for descriptive leaflet No. 177

SCALERS



GENERAL PURPOSE COUNTER *Type 1339 A*

★ **Designed and developed in conjunction with U.K.A.E.R.E.**

★ **Provides comprehensive scaling facilities for all types of Geiger Scintillation Counters.**

★ **Incorporates stabilised E.H.T. supplies.**

★ **Fitted with automatic timing control.**

This equipment is built on a unit basis and provides very comprehensive scaling facilities for all types of accurate assay work. It consists of two main units — a Power Unit and a Scaling Unit — together with a number of optional sub-units. These include a Quenching Unit, a High Speed Scaling Unit, an Amplifier/Discriminator Unit, a Paralysis Unit and a Timing Unit.

Full details are given in descriptive leaflet No. 185

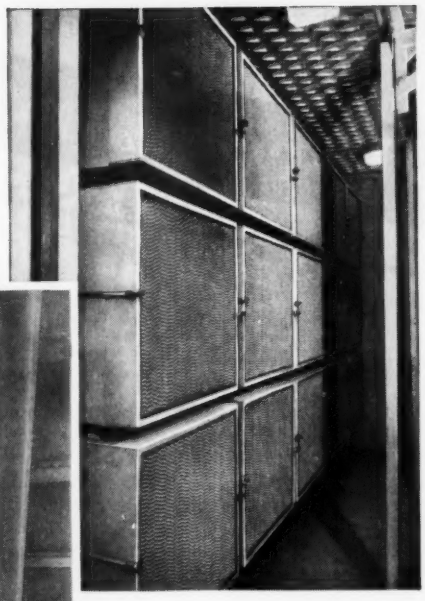
Airmec

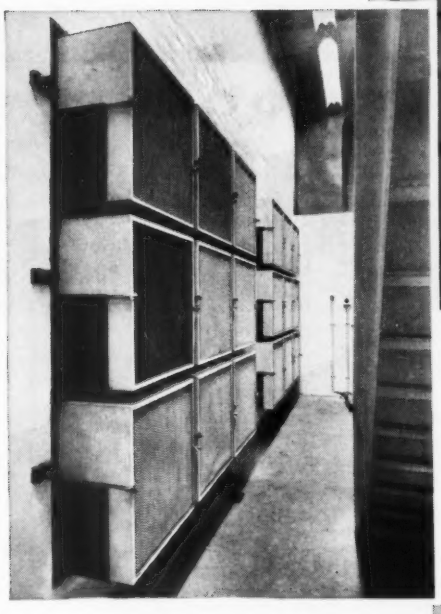
INSTRUMENTS FOR THE NUCLEONIC INDUSTRY

AIRMEC LIMITED · HIGH WYCOMBE BUCKS

Telephone : High Wycombe 2060

Vokes at Harwell

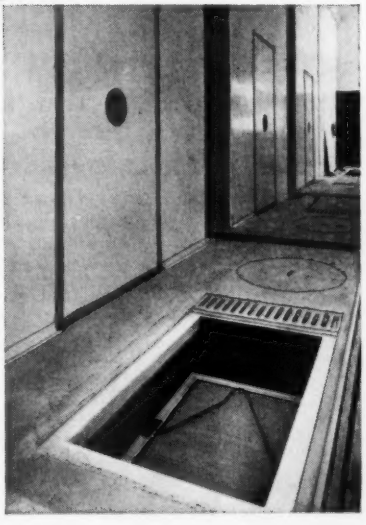




Vokes 44 'Absolute' filters on the intake side.

Vokes 55 'Absolute' filters on the extract side.

A Vokes 55 'Absolute' under-floor cell filter in the operating area.



In the High Activity Materials Handling Building at Harwell, Vokes 'Absolute' filters were specified by the Ministry of Works for the ventilation plant. Already in use at Aldermaston and Dounreay Vokes 'Absolute' filters provide the highest standard of filtration at present available — 99·95% tested efficiency against a methylene-blue dust cloud. Each filter is tested before despatch and is unreservedly guaranteed. Vokes 'Absolute' filters, and other Vokes types, are playing and will continue to play a vital part in Britain's nuclear power programme. Our engineers will be glad to give you full details of the Vokes 'Absolute' filter.

VOKES

VOKES LTD · GUILDFORD · SURREY

Telephone: Guildford 62861 (6 lines)

Telegrams & Cables: Vokesacess, Guildford, Telex

Telex: 13-535 Vokesacess, Gfd.

Vokes Australia Pty. Ltd., Sydney — *Represented throughout the World*

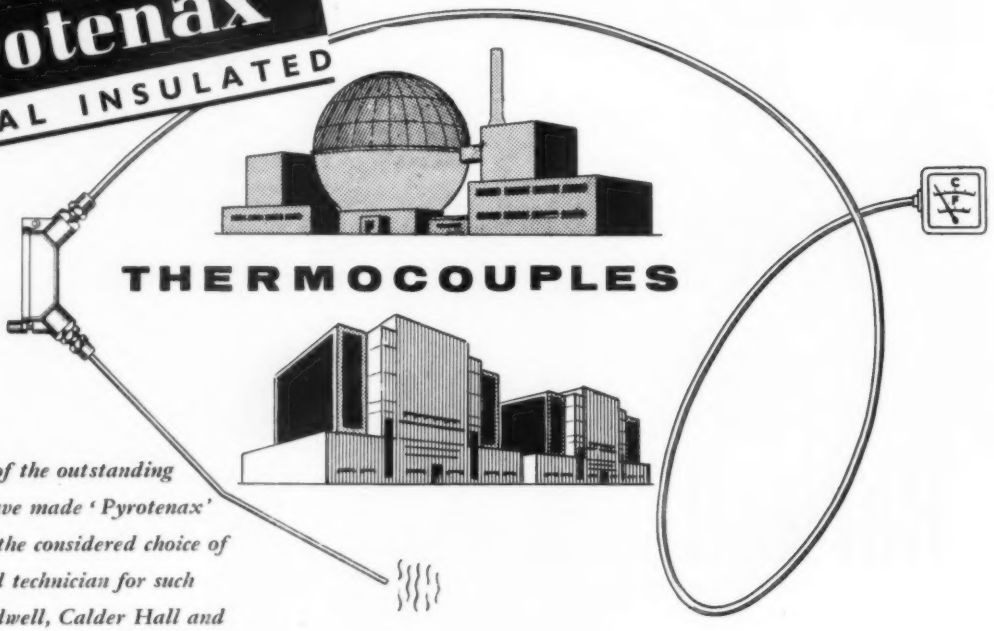
VOKES—Air and Gas Filters for Chemical, Nuclear Energy, Oil Refinery, and Pharmaceutical applications etc; Air conditioning filters; Compressed air pipe line filters, Air, Oil, and Fuel filters for Diesel, Gas Turbine, and other i/c engines; Hydraulic filters; Silencers for Engines, Fans and Blowers; High efficiency Multi Cyclones

V313

FEATURES THAT PROMPTED THE CHOICE OF

Pyrotenax

MINERAL INSULATED



THERMOCOUPLES

Here are some of the outstanding features that have made 'Pyrotenax' Thermocouples the considered choice of the scientist and technician for such projects as Bradwell, Calder Hall and Dounreay and in ever increasing quantity in Thermo-instrumentation generally.

EASILY BENT TO SHAPE

they are

IMMUNE FROM THERMAL SHOCK AND MECHANICAL DAMAGE

their

SMALL OVERALL DIAMETER

permits use in restricted spaces allowing simultaneous readings at different points, where normally only one conventional type could be sited, and generally

NO ADDITIONAL PROTECTIVE SHEATHING REQUIRED

resulting in a

RAPID RESPONSE RATE

comparable with that of mercury-in-glass thermometer

They have a

LONG LIFE

but, because they are

INEXPENSIVELY REPLACED

they may be used at temperatures far in excess of those normally permitted for economic operation.

'Pyrotenax' Thermocouples are supplied with conductors of COPPER/CONSTANTAN with either CUPRO-NICKEL or MILD STEEL sheath, conductors of NICKEL-CHROME/NICKEL ALUMINIUM ALLOY with NICKEL-CHROME STEEL sheath for high accuracy, high temperature applications.

Full technical details in publication 31/X109.

Use of the name "Pyrotenax" is exclusive to the products of this Company and its associates.

PYROTENAX LIMITED

HEBBURN-ON-TYNE

Telephone : Hebburn 83-2244/8

LONDON: *Abbey 1654/5* **BIRMINGHAM**: *Midland 1265* **MANCHESTER**: *Blackfriars 6946* **LEEDS**: *Leeds 27826* **GLASGOW**: *City 3641/2* **CARDIFF**: *Cardiff 23689*

GD109

Burst slug display

As the size of gas-cooled reactors increases, use of computer technique for burst slug detection and display, in place of the earlier recorder methods, becomes essential. The many advantages of a computer technique are illustrated by equipment now being made by Sunvic Controls.

- ★ Compact display with flexible programming facilities allows presentation of only that information required for immediate assessment of abnormal activity.
- ★ Individual channel group reference levels and differential limits: magnetic memory drum for previous 24 hours readings; facilities for averaging past values.
- ★ All results calculated to three significant figures —no calibration errors.
- ★ Completely self-checking circuitry with built-in fault-finding facilities.

The burst slug detection display system described above (for which patents are pending), was wholly developed by Sunvic engineers, who are available to discuss its application to any power reactor. Please contact:

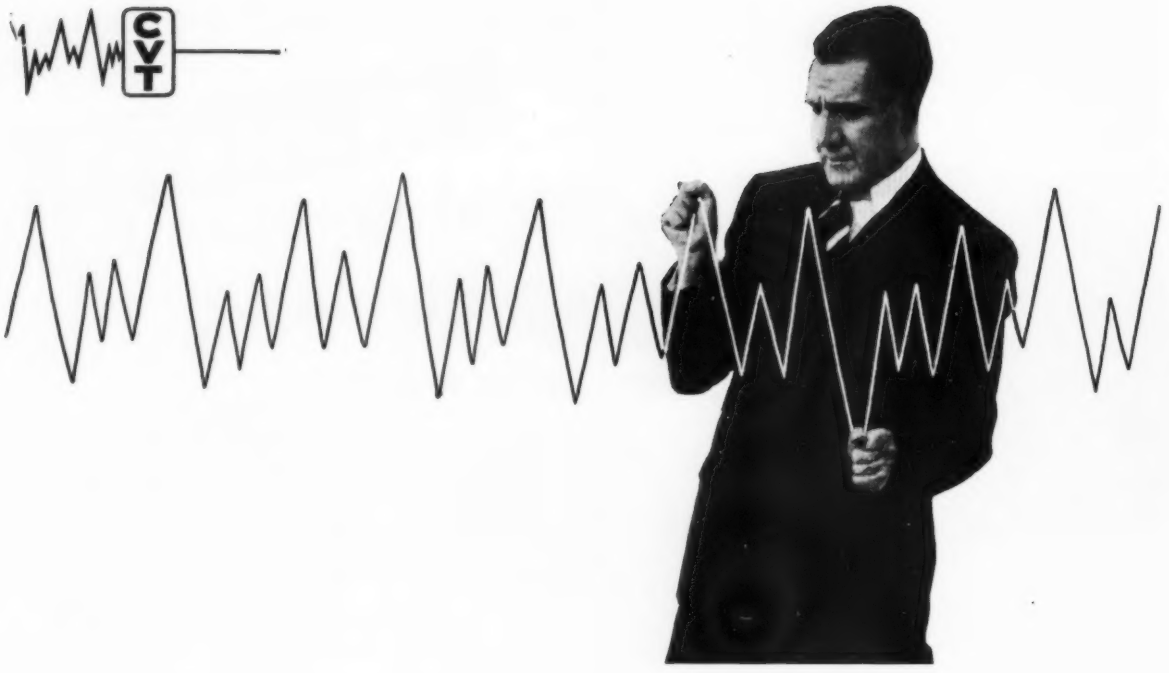
SUNVIC CONTROLS LTD
P.O. BOX 1 · HARLOW · ESSEX.
Tel: Harlow 25271

An artist's impression of the gas activity monitoring display equipment being built for C.E.G.B. use at the Berkeley nuclear power station by Sunvic, who are also supplying instrumentation for the boilers and blowers.

SUNVIC
An A.E.I. Company

Not only instruments but complete instrumentation
for integrated monitoring, control and data handling of nuclear reactors and industrial processes.

SC/66



Why struggle with Mains Voltage Fluctuation?

If you have any problem involving a.c. voltage regulation, the solution is to call in 'Advance' — the C.V.T. specialists.

Investigation of your problem may prove that a standard type Constant Voltage Transformer will meet the case; or maybe, a special design is called for. In either event, the wealth of experience gained by 'Advance' over many years in probing every aspect of mains stabilization provides the surest, quickest, and certainly the most economical, solution to your difficulties.

Advance

"VOLTAGE STABILIZATION"

This 'Advance' Booklet gives authoritative information on 'Advance' Constant Voltage Transformers, and the service available to deal with your particular voltage fluctuation problems. Send for a copy.

POST THIS COUPON TODAY ▶

Advance COMPONENTS LIMITED · ROEBUCK ROAD
HAINAULT · ILFORD · ESSEX · TELEPHONE: HAINAULT 4444

GD 10

CONSTANT VOLTAGE TRANSFORMERS

TO ADVANCE COMPONENTS LIMITED
ROEBUCK ROAD, HAINAULT, ILFORD, ESSEX

Please send me a copy of your booklet "Voltage Stabilization by Advance.

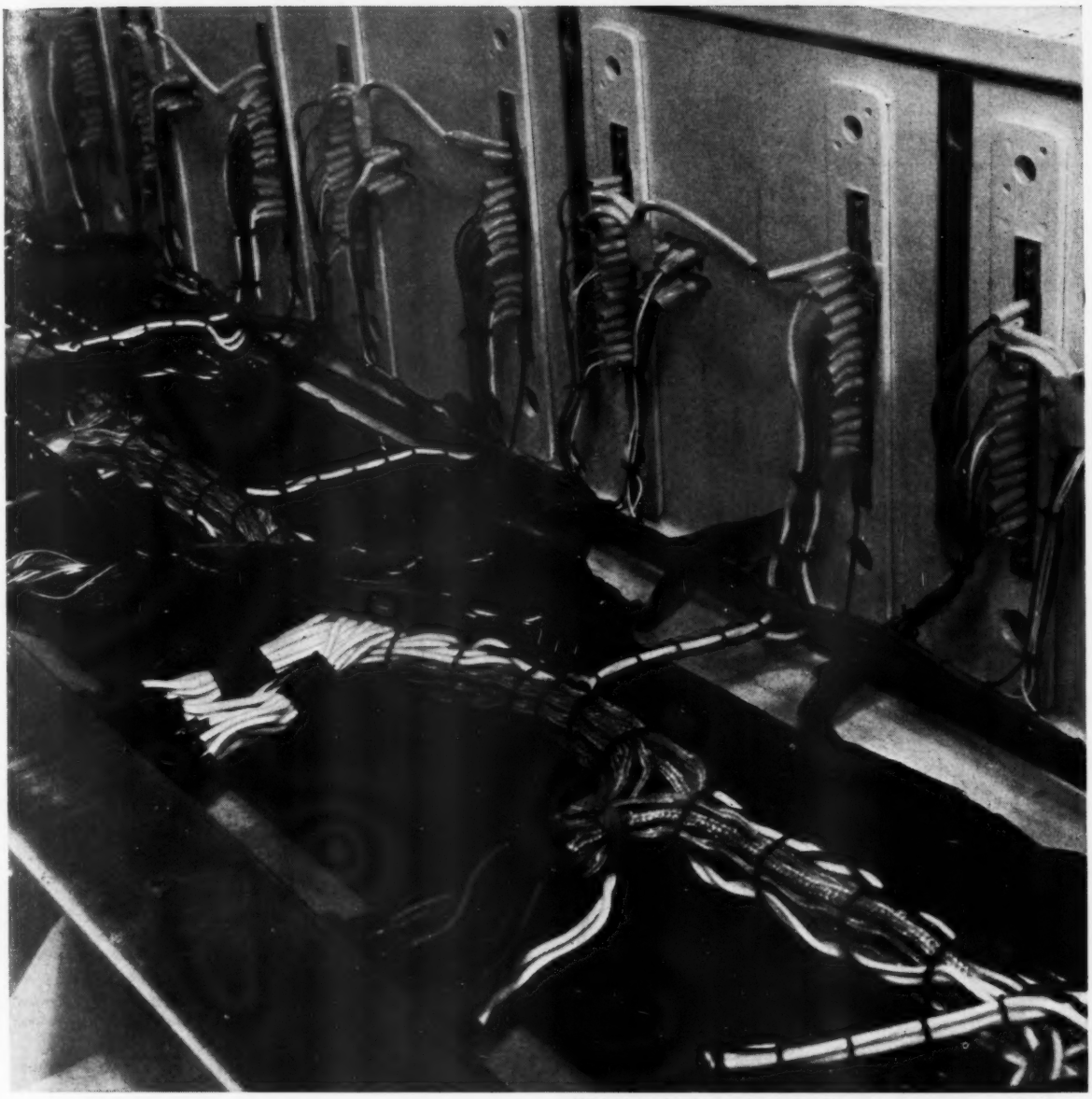
NAME .....

POSITION .....

COMPANY .....

ADDRESS .....

..... N 10



'Welvic' insulated and sheathed cables and sleeving on a cable harness loom made by Rists Wires and Cables Ltd., Newcastle-under-Lyme, Staffs.

When Rists Wires and Cables Ltd. use p.v.c. in cable harnesses

they use I.C.I. 'Welvic'

LEADING MANUFACTURERS use 'Welvic' p.v.c. compounds because, like all I.C.I. plastic materials, 'Welvic' is backed by the finest research and technical service in the country. That service is at your disposal. If there is anything you would like to know about the uses of p.v.c. in industry, have a word with I.C.I.

One of the most popular and valuable uses of p.v.c. is in wire and cable covering. Rists Wires and Cables Ltd. use p.v.c. insulated and sheathed cables for car harnesses as well as sleeving and shrouding. The p.v.c. is I.C.I. 'Welvic' compound.

'WELVIC'

'Welvic' is the registered trade mark for the p.v.c. compounds manufactured by I.C.I.

IMPERIAL CHEMICAL INDUSTRIES LIMITED · LONDON · S.W.1

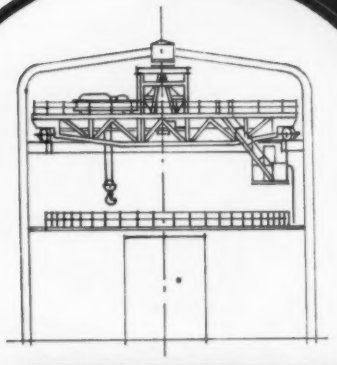
ICI

PC.24

Tick **No 31** on reply card for further details

CRANE MAKING

In the Atomic field



DIDO — PLUTO

In collaboration with the Ministry of Works Engineering Staff we designed and installed a special form of circular motion Overhead Electric Travelling Crane, for operation in Britain's first experimental Reactor at Harwell.

Further circular motion units have been installed at both Harwell and Dounreay, the latter on instructions from the United Kingdom Atomic Energy Authority.

Shortly we will commission a similar crane for the Australian Atomic Energy Commission.

The cranes are designed for a lift of 25 tons on a span of approximately 67 ft.

We are currently engaged in the installation of Main Turbine House and Blower House Cranes for Calder "B" and Chapelcross Atomic Power Stations.

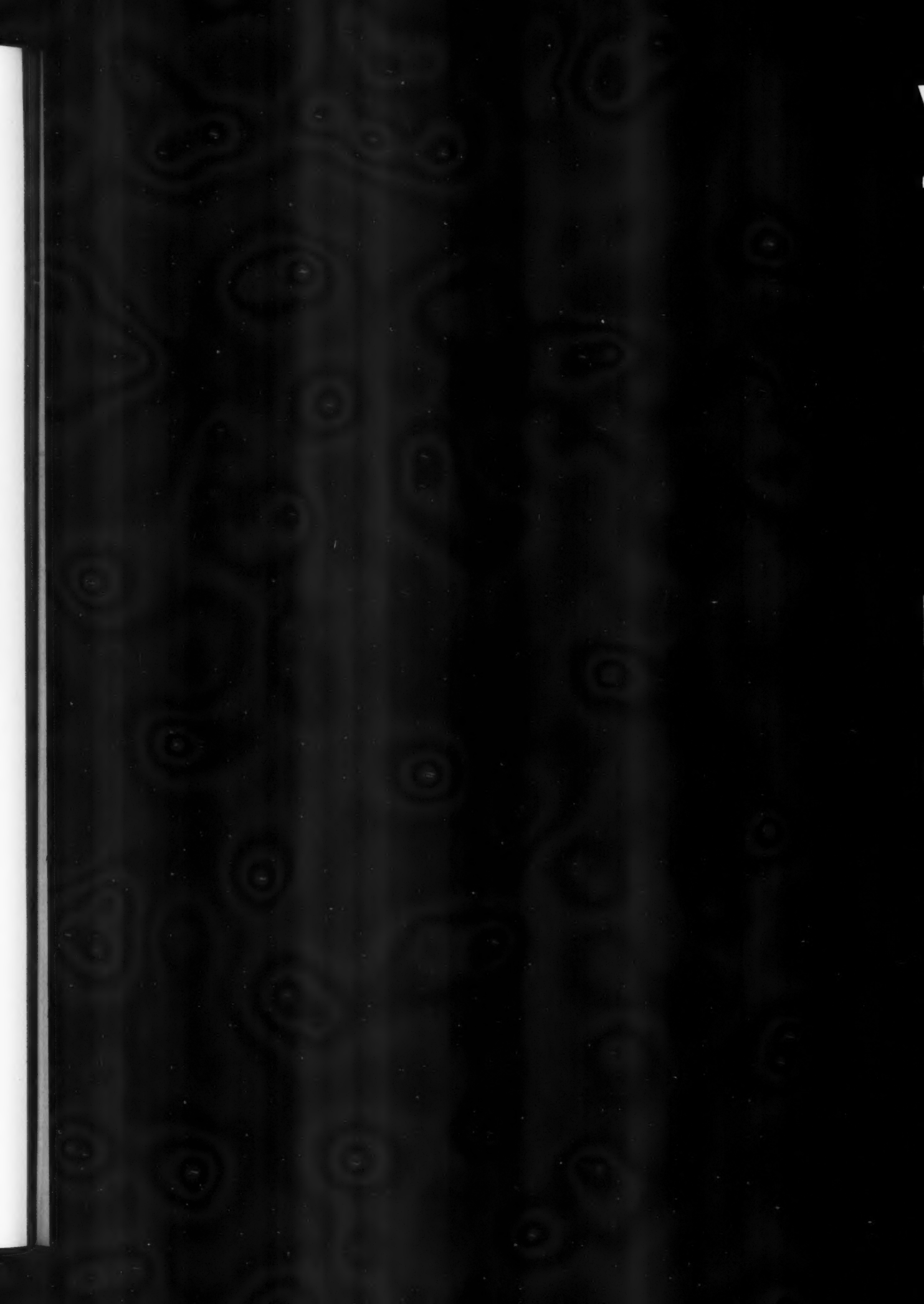
THE WHARTON CRANE & HOIST CO. LTD.

REDDISH STOCKPORT ENGLAND

Phone: Heaton Moor 2227. Grams: "Gallant, Manchester" Code: Western Union

LONDON: Lincoln House, 296/302 High Holborn W.C.1.	Phone: Chancery 7911.	Grams: Chancery 7911.
SCOTLAND: Fisher-Baxter & Co., 140 West George Street, Glasgow C.2.	Phone: Douglas 1061–2–3.	Grams: Fluorspar, Glasgow.
MIDLANDS: A. R. Holland & Son, 89 Cornwall Street, Birmingham 3.	Phone: Central 1457.	Grams: Central 1457, Birmingham.
SOUTH-WEST: R. C. Collins, 48 Westbourne Road, Penarth, Glamorgan.	Phone: Penarth 1527.	Grams: Penarth 1527.
NORTHERN COUNTIES: Fisher-Baxter & Co., 140 West George Street, Glasgow C.2.	Phone: Douglas 1061–2–3.	Grams: Fluorspar, Glasgow.
NORTHERN IRELAND: General Engineering Products Ltd., 7/9 Great Patrick Street, Belfast.	Phone: Belfast 23743.	Grams: Belfast 23743.
REPUBLIC OF IRELAND: Charles Nolan & Co., 2 Parker Hill, Lower Rathmines Road, Dublin.	Phone: Dublin 93510.	Grams: Dublin 93510.
CANADA: Marshall Equipment Co. Inc., P.O. Box 28, 61 Victoria Avenue, Dorval Station, P.Q.	Phone: Melrose 1–3528.	Grams: Marquipco, Montreal.

REPRESENTED IN PRINCIPAL COUNTRIES THROUGHOUT THE WORLD.



Nuclear Power
REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

free enquiry service for . . .

TECHNICAL LITERATURE

To help you keep right up to date in design, planning or actual buying, NUCLEAR POWER has compiled this list of advertised products and services under broad group headings. Study the advertisements and then simply tick the items about which you would like further details. Then post this form back to us and we will take immediate action to see you receive the information you want.

Ball bearings and bushings
- ☐ Ransome & Marles Bearing Co Ltd 8, 9

Carbon and graphite
- ☐ British Acheson Electrodes Ltd 115
- ☐ Nobrac Carbon Ltd 126
- ☐ Powell Duffryn Carbon Prod Ltd 2

Chemicals and plastics
- ☐ Imperial Chemical Industries Ltd 31
- ☐ Shell Chemical Co Ltd 47
- ☐ Thermal Syndicate, The 114

Construction, design and allied services
- ☐ High Voltage Eng Corp 95
- ☐ Holman Bros Ltd cover 4
- ☐ Rawlplug Co Ltd 25
- ☐ Screw Machine Products Ltd 136

Corrosion prevention
- ☐ Evode Ltd (Paints div) 10

Electric motors and gear units
- ☐ Electrical Power Eng Co (B'ham) Ltd 139

Electrical generating and subsidiary equipment
- ☐ Mirrlees, Bickerton & Day Ltd 42

Fans, ventilation and air conditioning equipment
- ☐ Vokes Ltd 27

Filters
- ☐ Streamline Filters Ltd 114

Gas, treatment, movement, control and storage
- ☐ General Electric Co Ltd, The 41

Heating plant and equipment
- ☐ Barlow-Whitney Ltd 137
- ☐ Edwards High Vacuum Ltd 116
- ☐ Electrothermal Eng Ltd 133
- ☐ Fraser & Fraser Ltd 134
- ☐ Superheater Co Ltd, The 49

Industrial films, books, models and exhibitions
- ☐ Blackwell's 113
- ☐ Butterworths Scientific Publications 112
- ☐ Cambridge University Press 113
- ☐ Energia Nucleare 125
- ☐ Engineering, Marine, Welding and Nuclear Energy Exhibition 55
- ☐ Mancuna Eng Ltd 111
- ☐ Nuclear Power Binder 125
- ☐ Nuclear Reactor Physics 128
- ☐ Wiggin & Co Ltd, Henry 109

Instrumentation and instrumentation components
- ☐ Advance Components Ltd 30
- ☐ Airmec Ltd 26
- ☐ Avo Ltd 136
- ☐ Bailey Meters & Controls Ltd 16
- ☐ British Rototherm Co Ltd 140
- ☐ Davison & Co (Hexham) Ltd 141
- ☐ Dynatron Radio Ltd 121
- ☐ Electronic Associates Inc 44
- ☐ EMB Co Ltd 119
- ☐ Imhof Ltd, Alfred 36
- ☐ Inglis Knibb & Co 137
- ☐ KDG Instruments Ltd 122
- ☐ Londex Ltd 128
- ☐ Lyons Ltd, Claude 132
- ☐ Pyrotenax Ltd 28
- ☐ Sangamo Weston Ltd 51
- ☐ Screw Machine Products Ltd 136
- ☐ Simmonds Ltd, L. E. 137
- ☐ Solartron Electronic Group Ltd, The 58, 97
- ☐ Sunvic Controls Ltd 29
- ☐ Westool Ltd 14, 15
- ☐ West Instruments Ltd 138

Insulation
- ☐ Cape Asbestos Ltd 45
- ☐ Darlington Insulation Co Ltd, The 50
- ☐ Newalls Insulation Co Ltd 35
- ☐ Versil Ltd 38, 39

Insurance
- ☐ Evers, D. H. 127

Laboratory equipment
- ☐ Endecotts (Filters) Ltd 141
- ☐ Pascall Eng Co Ltd 138

Lubrication
- ☐ Shell Mex & BP Ltd 100, 101
- ☐ Wakefield-Dick Industrial Oils Ltd 107

Mechanical handling
- ☐ EMB Co Ltd 119
- ☐ Moore Ltd, W. & E. 135
- ☐ Paterson Hughes Eng Co Ltd 37
- ☐ Wharton Crane & Hoist Co Ltd 32

Metals: fabrication, machining, machinery and products
- ☐ Allen & Sons (Tipton) Ltd, W. G. 135
- ☐ Armstrong Siddeley Motors 12
- ☐ Armstrong Whitworth Aircraft Ltd, Sir W. G. 118
- ☐ Associated Lead Mfgs Ltd 21
- ☐ Atlas Steel Foundry & Eng Co Ltd 131
- ☐ Barker & Sons (Eng) Ltd, John 138
- ☐ Birmetals Ltd 52
- ☐ Bramah & Co Ltd, J. R. 132
- ☐ Clay Cross (Iron & Foundries) Ltd 40
- ☐ Cox & Danks Ltd 53
- ☐ Darham Industries (London) Ltd 130
- ☐ Graviner Ltd 120
- ☐ Grazebrook, M. & W., Ltd 134
- ☐ Harvey & Co (London) Ltd, G. A. 20
- ☐ Highfield Gear & Eng Co Ltd 136
- ☐ Ide Eng Ltd, C. F. 139
- ☐ Imperial Chemical Industries (Metals div) 56
- ☐ Kennedy & Co Ltd, Allan 19
- ☐ Marston Excelsior Ltd 48
- ☐ Mollart Eng Co Ltd 22
- ☐ Mulberry Co, The 118
- ☐ Murex Ltd (Powder Metallurgy div) 120
- ☐ Norwood Steel Equipment Ltd 103
- ☐ Premier Precision Ltd 105
- ☐ Screw Machine Products Ltd 136
- ☐ Sheepbridge Alloy Castings Ltd
- ☐ Smith & Sons (Clerkenwell) Ltd, J. 133
- ☐ Southborough Group 134
- ☐ Stainless Steel Profile Cutters Ltd 144
- ☐ Steel, Peech & Tozer 54
- ☐ Suffolk Iron Foundry (1920) Ltd 139
- ☐ Universal Boilers & Eng Co Ltd 5
- ☐ Vokes Genspring Ltd 140
- ☐ Walker Ltd, C. & W. 129
- ☐ Yarrow & Co Ltd 140

Office equipment
- ☐ Photostat Ltd 116

Power station equipment
- ☐ DP Battery Co Ltd 24
- ☐ Whipp & Bourne Ltd 4
- ☐ Williams & James (Eng) Ltd 141

Pumps, valves (liquid and gas)
- ☐ Erhard, Johannes 18
- ☐ Harland Eng Co Ltd, The 117
- ☐ Techniques Nucléaires 122
- ☐ Worthington-Simpson Ltd 13

Radiography and radiographic equipment
- ☐ Metal & Pipeline Endurance Ltd 130
- ☐ Research & Control Instruments Ltd 3

Reactor construction
- ☐ ACF Industries Inc 43
- ☐ Simon-Carves Ltd (nuclear power div) 17

Reactor equipment
- ☐ Ayling Nuclear Equipment Co 7
- ☐ General Electric Co Ltd, The 41
- ☐ Serck Radiators Ltd 11
- ☐ Serck Tubes Ltd 11
- ☐ Techniques Nucléaires 122

Remote handling
- ☐ Ayling Nuclear Equipment Co 7
- ☐ Savage & Parsons Ltd cover 2

Shielding
- ☐ Mallinson & Sons Ltd, Wllm 121

Tools
- ☐ Abingdon King Dick Ltd 129

Tubes, pipes seals and couplings etc
- ☐ Kirk & Co (Tubes) Ltd 131
- ☐ Simplifix Couplings Ltd 126
- ☐ Stanton Ironworks Co Ltd cover 3
- ☐ Teddington Aircraft Controls Ltd 6
- ☐ Weston & Co Ltd, Chas 23

Welding and welding equipment
- ☐ Lincoln Electric Co Ltd 46

please send me further information on the above items which I have ticked/or on the following editorial pages **94-96-98**

NAME **POSITION**

ADDRESS

Note that no stamp is needed in United Kingdom

Tuck in this end

This service is designed to give you advice or fuller information on any subject, or service mentioned in this issue—whether in the editorial text or in an advertisement—free of charge

Fold Here

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
3 Percy Street,
London, W1
England

Fold Here

Fold Here First

Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

FREE ENQUIRY SERVICE

and

SUBSCRIPTION SERVICE

Do you see

NUCLEAR POWER

regularly?

Through your not seeing even one monthly issue you may have missed something really important in the constantly changing nuclear picture

You can be sure of receiving Nuclear Power regularly every month by simply completing this coupon

Please enter me as a subscriber to Nuclear Power for one year :

United Kingdom	£2 . 2 . 0
Other Countries	£3 . 3 . 0
USA and Canada	$8.00 + 50c postage

starting with the.....issue

☐ and invoice me later
☐ subscription enclosed

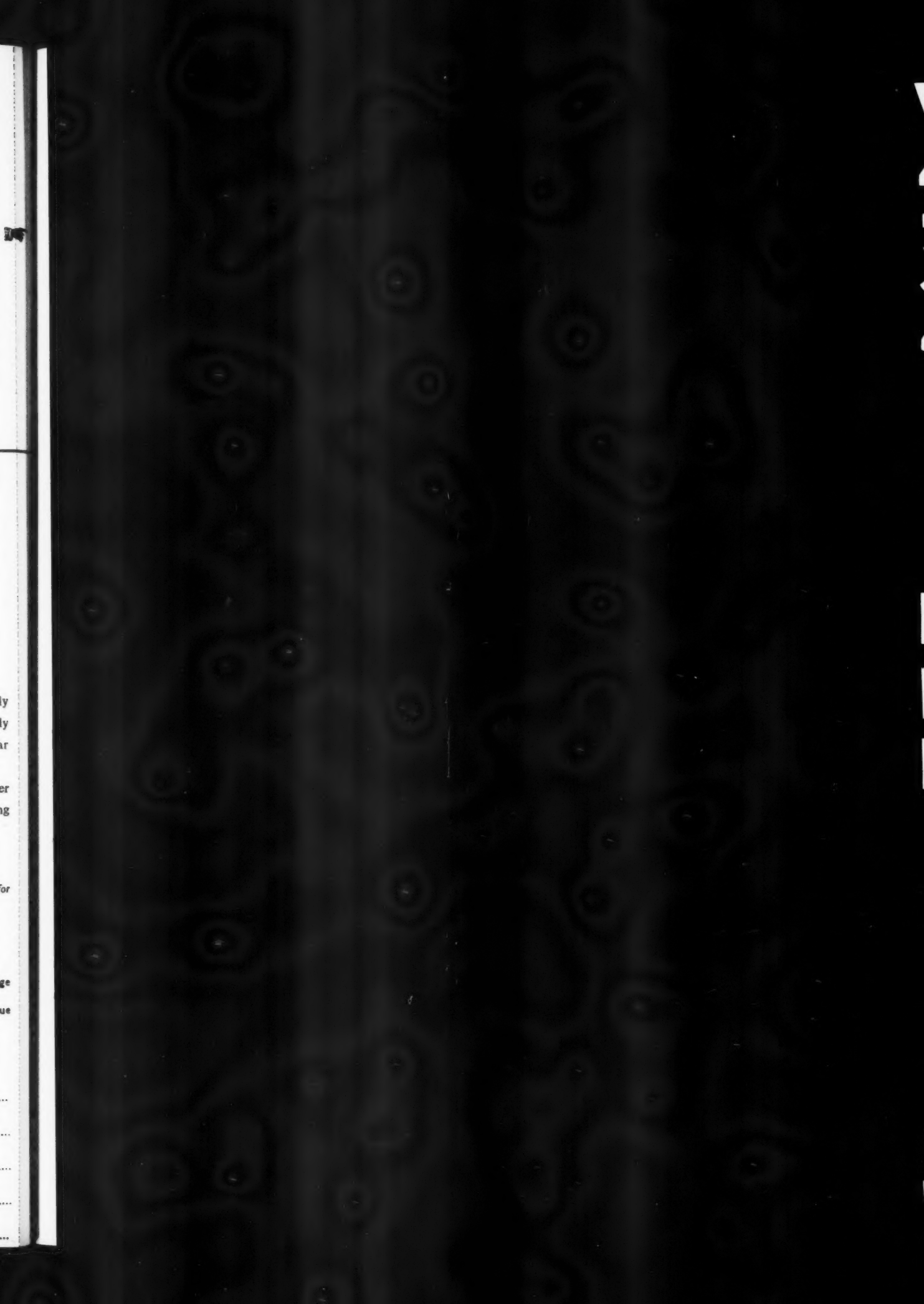
NAME.....

ADDRESS.....

.....

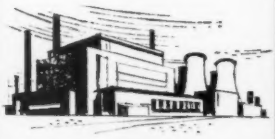
.....

POSITION .....



THERMAL INSULATION BY Newalls

Newalls have carried out the thermal insulation contracts on many of the British Power Stations built since the war.



CHAPELCROSS ▶

As a result of this specialised experience, Newalls have been successful in obtaining very large thermal insulation contracts at Chapelcross, now being constructed under Britain's Atomic Energy Development Plan.

NEWALLS INSULATION CO. LTD. WASHINGTON · CO. DURHAM

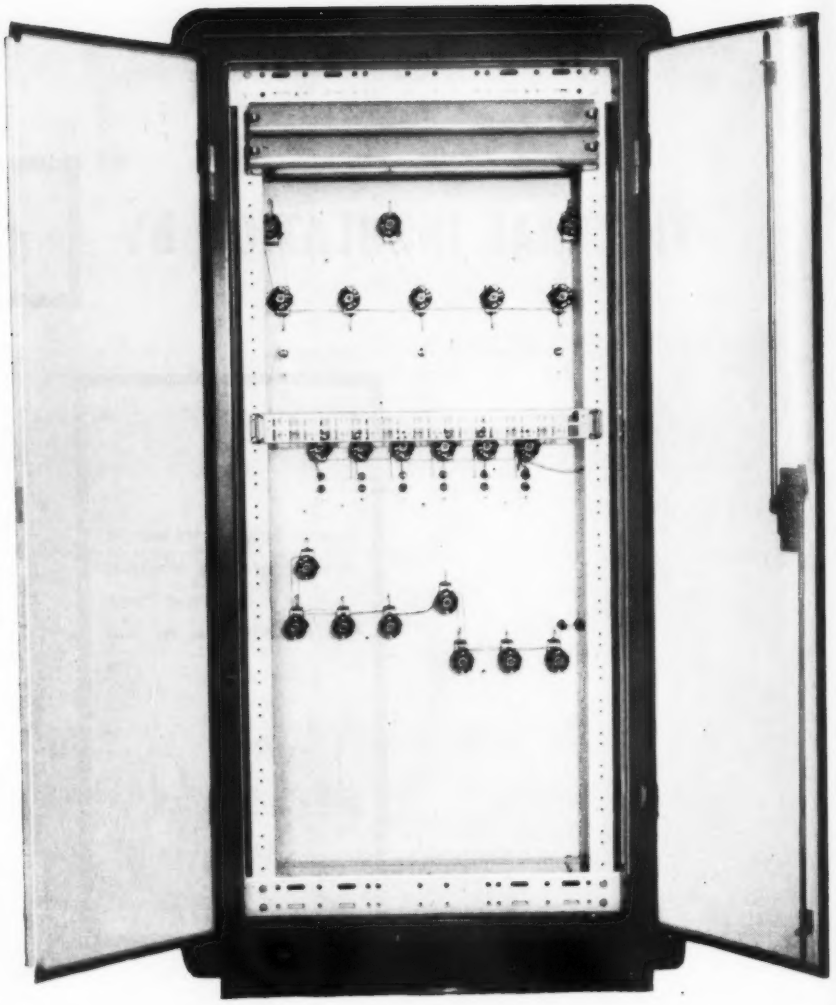
A member of the TURNER & NEWALL ORGANISATION

Offices and Depots at: LONDON . GLASGOW . MANCHESTER . NEWCASTLE UPON TYNE BIRMINGHAM . BELFAST . BRISTOL & CARDIFF. *Agents and Vendors in most markets abroad*

Tick **No 33** on reply card for further details

Typical example of an Imhof standard electrical cubicle fitted with control gear. Rear view shows partly assembled equipment in position. Imhof electrical cubicles enhance and protect the equipment they house and add much to the pleasantness of the operator's surroundings.

IMHOFS



standardised heavy-duty electrical cubicles

Two versions—*one for controls, one for apparatus* **Two standard sizes** *for each version* **Rigid, all-steel construction**

Reduce the cost of housing control gear or apparatus with Imhof *standardised* electrical cubicles. After intensive research into the needs of the electrical industry, Imhofs have designed these strong, attractive cubicles to an exacting specification which will meet most engineers' requirements. Available in single or bayed-up multiple units, they are a worthy addition to the already famous Imhof standard range of instrument cases, racks and consoles. Fully descriptive literature on request : just phone, or write on your Company's letterhead.

ALFRED IMHOF LTD. Dept: N 2 Ashley Works Cowley Mill Rd Uxbridge Middx: UX5-5567
Export & London Showrooms: 112-116 *New Oxford Street WC1: MUSeum* 7878

3-WAY ADJUSTABLE INTERNAL FRAMEWORKS for mounting equipment.

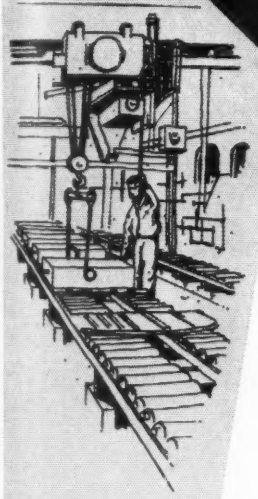
DOUBLE-SKINNED REAR DOORS fitted to both versions ... fully gasketed and mounted on robust lift-off hinges. Positive 3-point lever-type lock ensures safe sealing. Similar doors fitted to fronts of apparatus cubicles. Control cubicles have formed 10swg front panels.

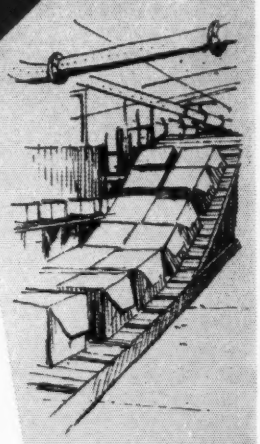
WIDE CHOICE OF FINISHES AND OPTIONAL EXTRAS Standard finishes: silver, light and dark grey hammertone, or high-gloss grey. Chrome-plated handles and hinges. Two-colour finishes to order. Front panels, with mimic diagrams, punched and drilled to individual requirements. Internal strip lighting, including switches and wiring, also supplied.

IMHOFS AGENTS OVERSEAS

AUSTRALIA Aladdin Industries (Pty) Ltd, Stanmore N.S.W.
BELGIUM Rogelec, Ghent
CANADA Measurement Engineering Ltd, Arnprior
DENMARK Tage Schouboe, Copenhagen N
FINLAND Oy Scienta Ab, Helsinki
HOLLAND J.Th. van Reijsen, Delft
ITALY Prodel SPA, Milan
NEW ZEALAND Imarex Ltd, Auckland C3
NORWAY Birger Christensen, Oslo
SWEDEN Elektronlund AB, Malmo C
SWITZERLAND Walter Blum, Zurich 2/39
U.S.A. Bud Radio Inc, Cleveland 3, Ohio
BRIT. GUIANA British Caribbean Agencies Ltd, Georgetown, Demerara

PATERSON HUGHES
ENGINEERING COMPANY LIMITED





UNITED DIVISIONS

The united efforts of specialist engineering divisions concentrated upon particular aspects of mechanical handling, enable Paterson Hughes to plan and design integrated handling and production schemes specially suited to particular requirements. Large design and manufacturing resources, and first-class installation and maintenance service ensure that Paterson Hughes mechanical handling equipment gives complete and continued satisfaction. Engineers are always available to discuss your problems.

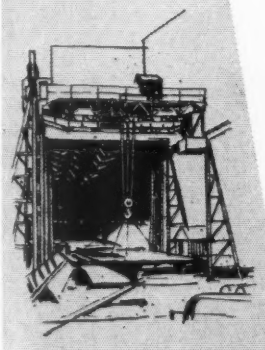
MECHANICAL HANDLING ENGINEERS & CRANE MAKERS

FOUNDRY DIVISION

The Foundry Division has long experience in the foundry industry. Many examples of Paterson Hughes pouring runways, conveyor systems, complete sand handling plants, cupola charging plants, casting cooling conveyors, are at work throughout the industry today.

CRANE DIVISION

Paterson Hughes electric overhead travelling cranes up to 100 tons capacity are manufactured in the modern crane works in Glasgow. Competitive prices and exclusive design features have put Paterson Hughes cranes in the forefront of the industry.

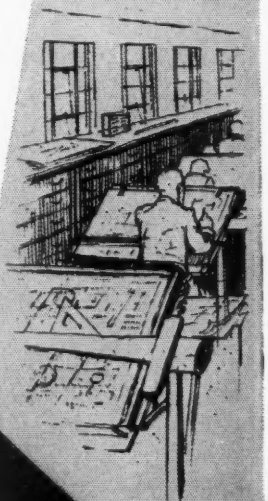


INDUSTRIAL HANDLING DIVISION

Conveyor and elevator systems of all types for the handling of bulk materials, packaged goods and unit articles are undertaken for all industries. Paterson Hughes conveyor systems have ensured higher and smoother production flow in many well-known factories.

DESIGN FACILITIES

Design capacity is always available to assist clients not only in the planning and layout of mechanical handling systems, but also for the development of new projects and new machines. Strategically placed area offices enable close liaison to be maintained.



BIRMINGHAM
3 Highfield Road
Edgbaston Birmingham 15
Phone: Edgbaston 2957-8

GLASGOW
Wyndford Works
Maryhill Glasgow
Phone: Maryhill 2172-4

SOUTH AFRICA—Paterson Hughes Engineering SA (PTY) Ltd PO Box 811 Johannesburg

LONDON—Bedford House Bedford Street London WC2 Phone: Temple Bar 7274-6

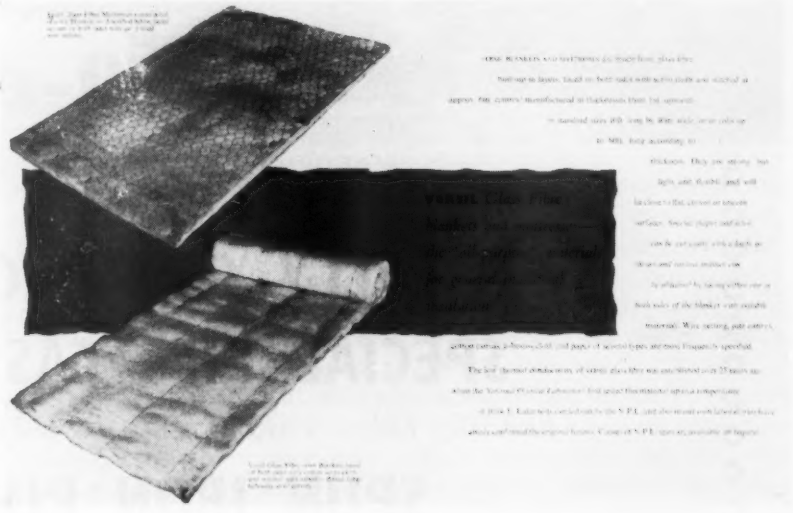
P.9114

Tick **No 35** on reply card for further details

NATTER, NATTER, NATTER...

"*Silly old fossil*—does he think I eat the stuff or something? What's the use of nattering on all the time about saving more fuel? Doesn't he know that I've got the whole factory fuel-economy mad, that we're doing everything we can, that I've looked into everything that could possibly..."

But have you, Sir? Have you looked into better insulation with VERSIL Glass Fibre? If not, concealed heat losses may be the weak link in your armour. *VERSIL is so easy to install, to handle and to maintain. But above all, there is not a more efficient insulating material in the whole wide world.* Challenge us to prove it. Write to Versil Ltd, Rayner Mills, Liversedge, Yorkshire. Telephone Cleckheaton 640.

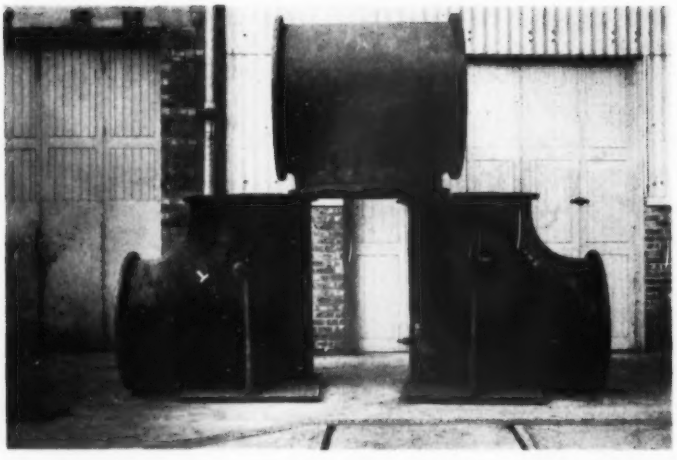


What You Need Is Versil

THE GLASS FIBRE INSULATION

Tick **No 37** on reply card for further details

CLAY CROSS



for
water
cooling
and
drainage
systems

VERTICALLY CAST IRON PIPES
SPECIAL PIPE CASTINGS

BENDS, TEES, TAPERS, ETC. UP TO 84" DIAM.

SPUN IRON PIPES

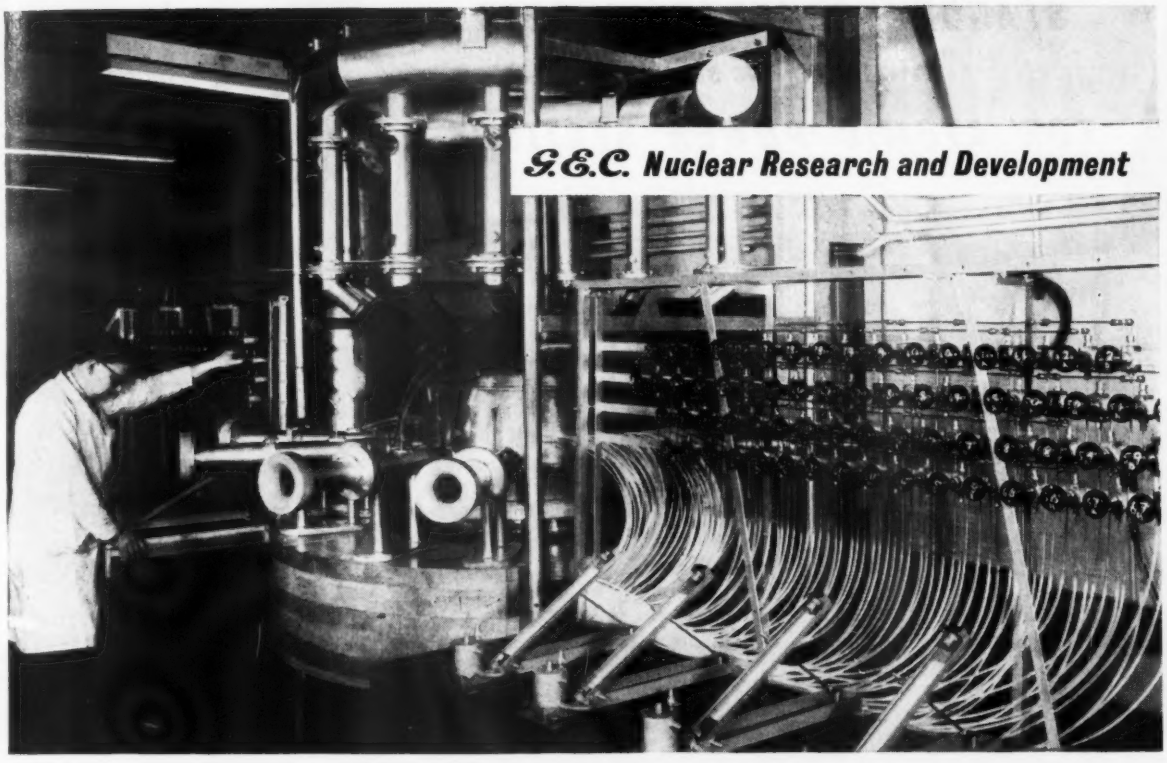
SCREWED SPUN FLANGED

work in progress for the nuclear industry

CLAY CROSS (IRON & FOUNDRIES) LTD.

CLAY CROSS, DERBYSHIRE

Telephone: Clay Cross 2151 *Telegrams: Jackson, Clay Cross*



Gas-flow model

In a gas-cooled reactor, there is an optimum value for the flow of coolant gas through each fuel channel to provide a given heat output. The flow must therefore be regulated, according to the power level, to achieve the maximum thermal efficiency of the system and to ensure that the operating temperature of the fuel elements is within the limits imposed by metallurgical and nuclear considerations.

There will be over 3000 vertical fuel channels in the 50 ft. diameter cylindrical core of each of the two reactors being built at Hunterston by G.E.C. A great deal of the theoretical and experimental work necessary to develop a design in which the total gas flow is correctly distributed over these channels has been done with the help of the gas-flow model shown above. This is a 1/20-scale model of a power reactor of the Hunterston type, and is installed in the laboratories of the G.E.C. Atomic Energy Division at Erith.

A 42-inch-diameter perspex sphere—which is a scale replica of the reactor pressure vessel complete with its supporting skirt, and rings of inlet and outlet gas-ports—houses a duralumin model of the reactor core. This core rests on a support-grid of the same "egg-box" type employed in the actual reactor. The channels for the fuel elements and control rods are represented by tubes whose number and diameter are such that the complete core offers a resistance to gas flow in proportion to the full-scale structures.

A motor-driven blower, coupled to the outlet ports in the sphere, draws air through the model to stimulate the flow of coolant gas in the reactor. Measurements are made of the air flow and the pressure drop along selected channels through the core using the pressure tubes and manometers on each side of the model.

Thus it is possible to investigate the symmetry of the gas flow through the reactor, and to study the effect of shutdown of one or more of the eight gas circuits connecting the pressure vessel to the steam-raising units. The influence of "gags", to restrict the flow of gas through the channels, can also be determined. This should save considerable time during the commissioning of the reactors.

G.E.C.

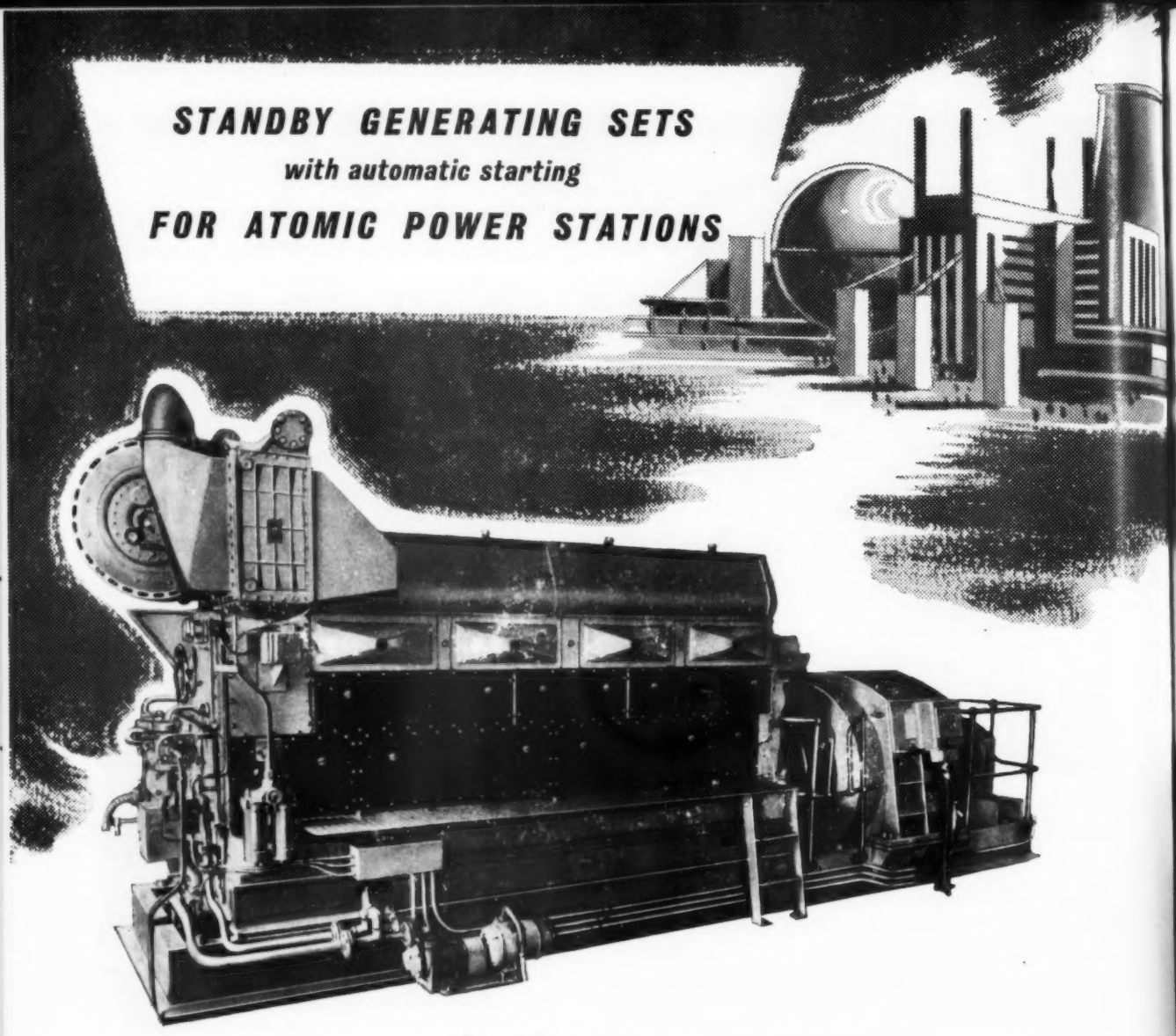
Atomic Energy Division

THE GENERAL ELECTRIC COMPANY LIMITED, MAGNET HOUSE, KINGSWAY, LONDON, W.C.2.
A284

STANDBY GENERATING SETS

with automatic starting

FOR ATOMIC POWER STATIONS



Mirrlees

diesels

Within a few seconds of receiving the starting signal and without manual attendance, these Mirrlees oil-engine sets will carry full load, providing a reliable auxiliary and standby supply for atomic power stations and other installations where it is essential to forestall breakdowns and serious loss due to cessation of mains power supply.

The Mirrlees J and JV Types of engine cover a comprehensive series including 3, 4, 5, 6 and 8-cylinder in-line engines and 12 and 16-cylinder vee-form engines. All can be offered in naturally aspirated or turbocharged form, the latter with or without air aftercoolers. The power range extends from the 210 BHP J3 three-cylinder naturally aspirated up to the 2272 BHP JVSS16 sixteen-cylinder turbocharged engine with air aftercooler.

MIRRLEES, BICKERTON AND DAY LIMITED

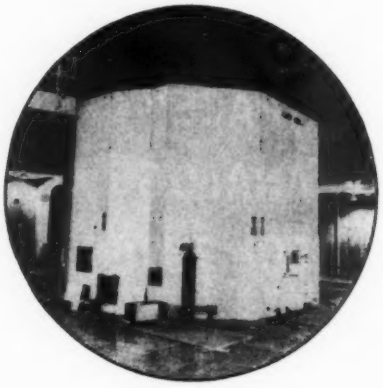
HAZEL GROVE · STOCKPORT · CHESHIRE

A member of the HAWKER SIDDELEY Group

Tick **No 40** on reply card for further details

Telephone: Stepping Hill 1000 (14 lines) *Telegrams:* "Mirrlees Telex, Manchester"

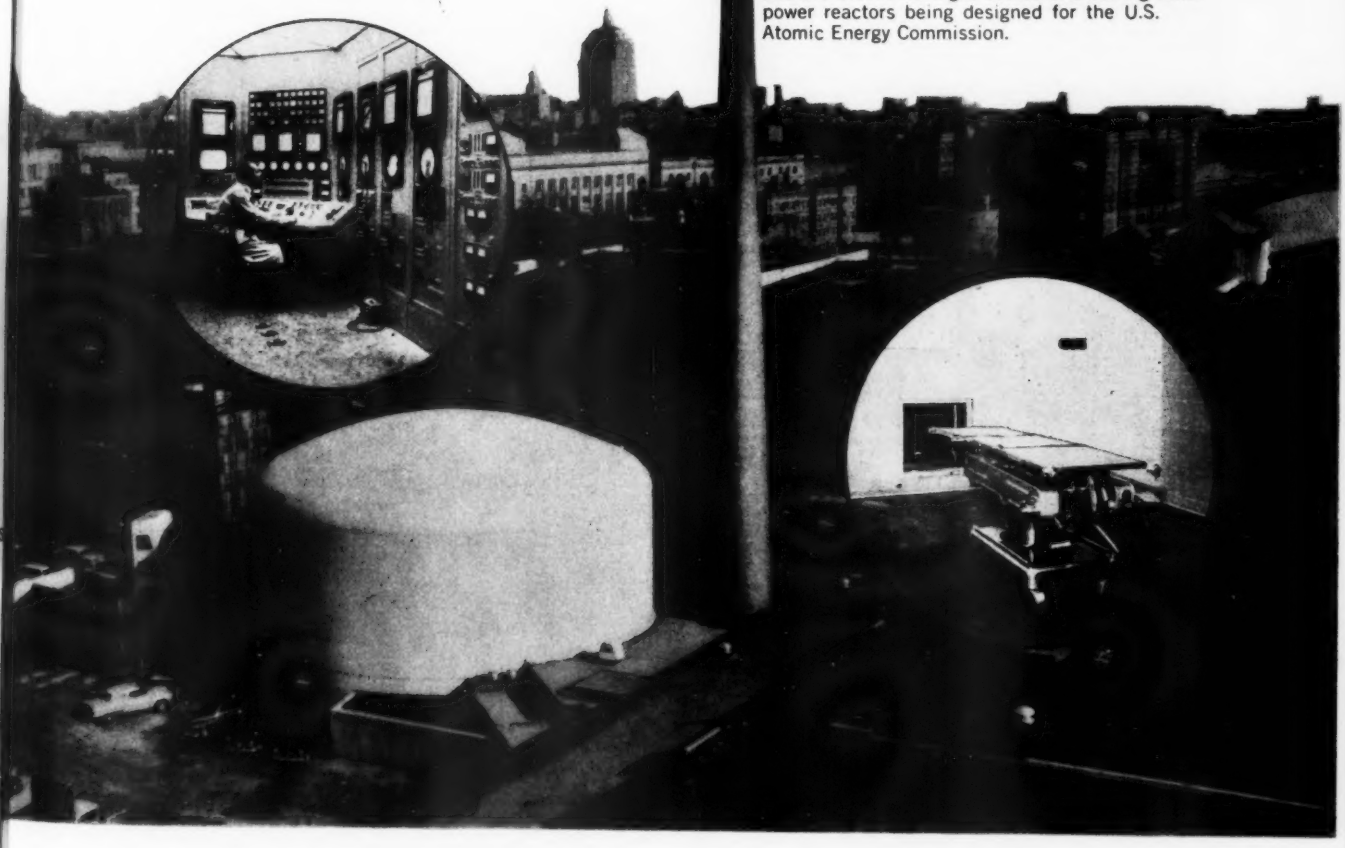
MITR
atoms for peace . . . a reality



With the completion of the world's first privately owned heavy water research reactor, at the Massachusetts Institute of Technology, comes a new and powerful instrument to further man's knowledge in the peacetime use of atomic energy. As prime contractor responsible for the complete engineering design and construction of this facility, ACF Industries, Incorporated is proud to join with MIT in this achievement.

The MITR will operate at 1000KW and produce fluxes in excess of 10^{13}n/cm²/sec. This inherently safe facility, located near the campus, includes a unique medical therapy room providing entirely new approaches to nuclear medical research techniques — a full range of experimental ports and thimbles — gamma irradiation room — chemistry hot labs — reactor control room — and equipment for servicing the reactor building.

Other ACF nuclear projects include research and test reactors under construction in Italy, Holland, Sweden and the U.S. . . . and gas cooled and boiling water power reactors being designed for the U.S. Atomic Energy Commission.

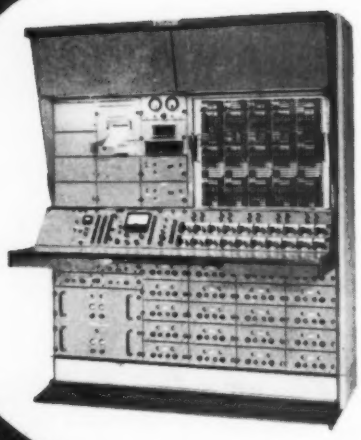


acf **NUCLEAR PRODUCTS—ERCO**

Division of acf Industries Incorporated

508 Kennedy Street N.W Washington 11, D.C.

Tick **No 41** on reply card for further details

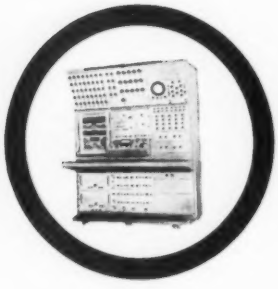


The new 231 R Computer can hold up to 100 amplifiers and other related non-linear equipment. New removable patch panel greatly speeds programming. Optional items include digital potentiometers and ADIOS (automatic digital input-output system)

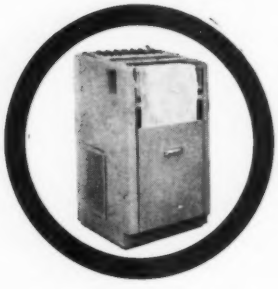
NEW "PACE" ANALOG COMPUTER 231 R...

... with highest precision : 0,01 %

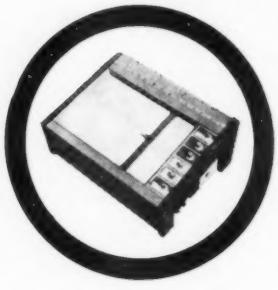
Dataplotter 1133 A.



131 R Analog Computer

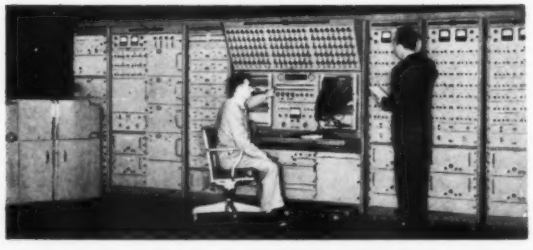


Eight Channel Rectilinear Recorder 1902-D.



Variplotter 1100-D.

Electronic Associates, Inc. has been the world's leading producer of Analog Computers and Plotting Equipment or over 5 years. For further information on their PACE Equipment the European Sales Office and Computation Center at Brussels is ready to assist European Industry



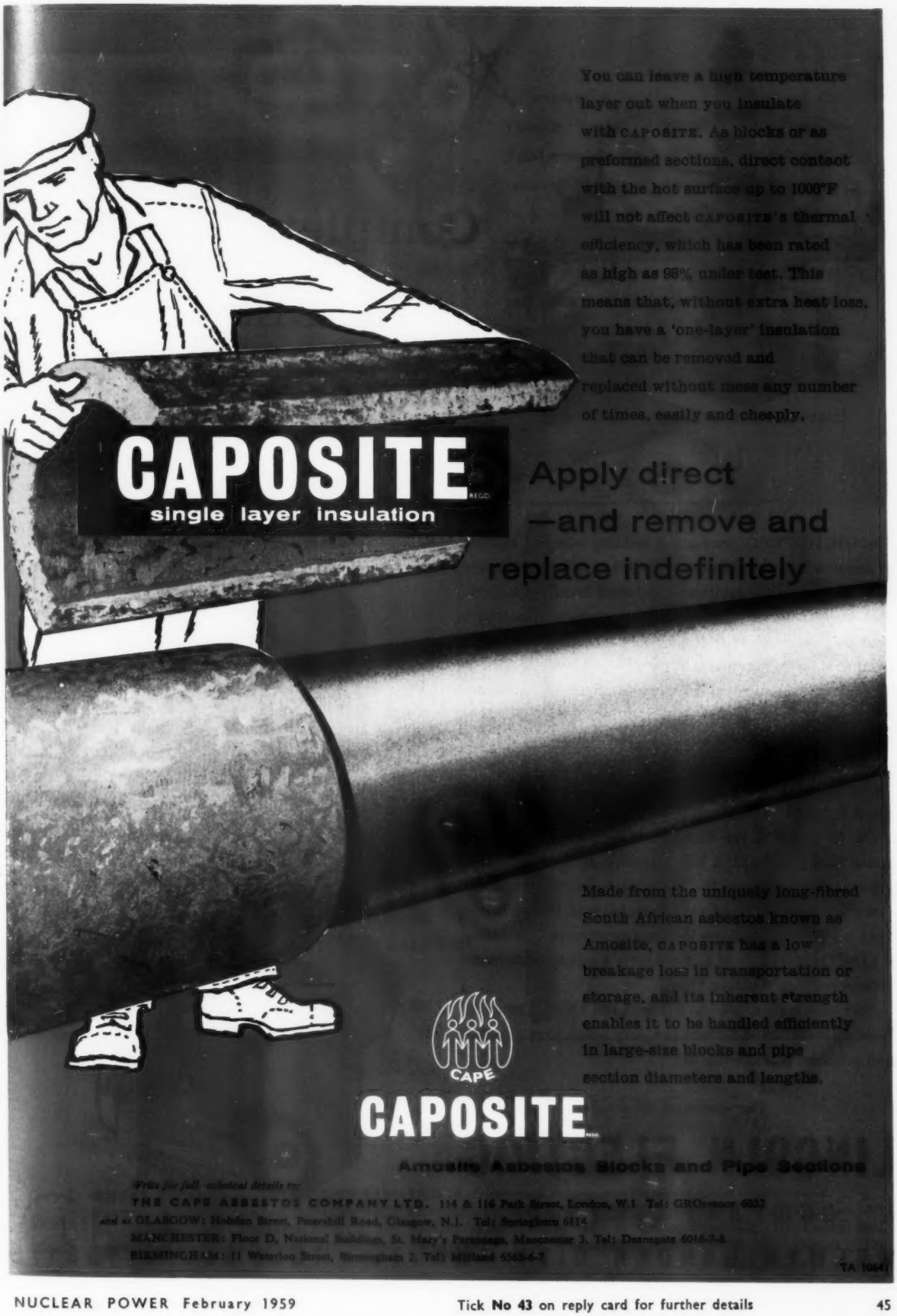
Rental facilities at European Computation Center in Brussels. Electronic Associates Application engineers are available to assist clients with their problems.

PRODUCERS OF "PACE" ANALOG COMPUTERS

ELECTRONIC ASSOCIATES, INC.

EUROPEAN SALES OFFICE AND COMPUTATION CENTER

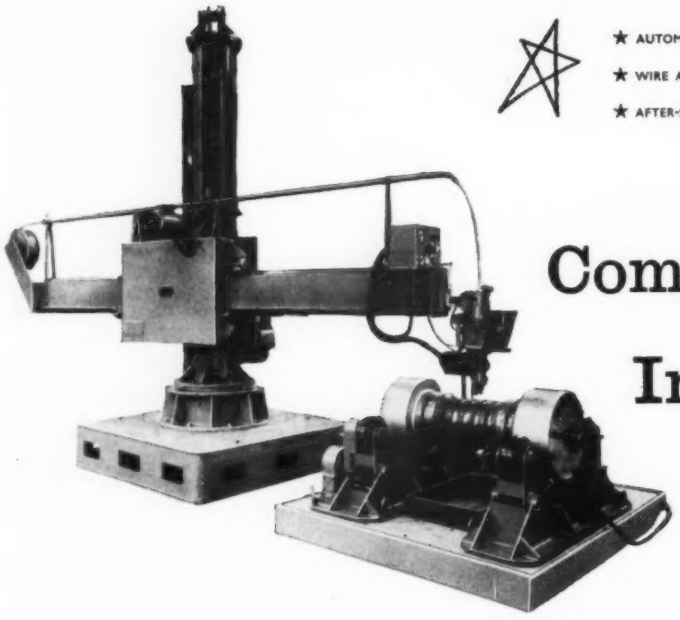
43, rue de la Science - Brussels - Belgium - Tel. 11.43.69


You can leave a high temperature layer out when you insulate with CAPOSITE. As blocks or as preformed sections, direct contact with the hot surface up to 1000°F will not affect CAPOSITE's thermal efficiency, which has been rated as high as 98% under test. This means that, without extra heat loss, you have a 'one-layer' insulation that can be removed and replaced without mess any number of times, easily and cheaply.
CAPOSITE REGD.
single layer insulation
Apply direct —and remove and replace indefinitely
Made from the uniquely long-fibred South African asbestos known as Amosite, CAPOSITE has a low breakage loss in transportation or storage, and its inherent strength enables it to be handled efficiently in large-size blocks and pipe section diameters and lengths.
CAPE
CAPOSITE REGD.
Amosite Asbestos Blocks and Pipe Sections
Write for full technical details to:
THE CAPE ASBESTOS COMPANY LTD. 114 & 116 Park Street, London, W.1 Tel: GROsvenor 6022
and at GLASGOW: Hobden Street, Petershill Road, Glasgow, N.1. Tel: Springburn 6114
MANCHESTER: Floor D, National Buildings, St. Mary's Parsonage, Manchester 3. Tel: Deansgate 6016-7-8
BIRMINGHAM: 11 Waterloo Street, Birmingham 2. Tel: Midland 5565-6-7
TA 1064

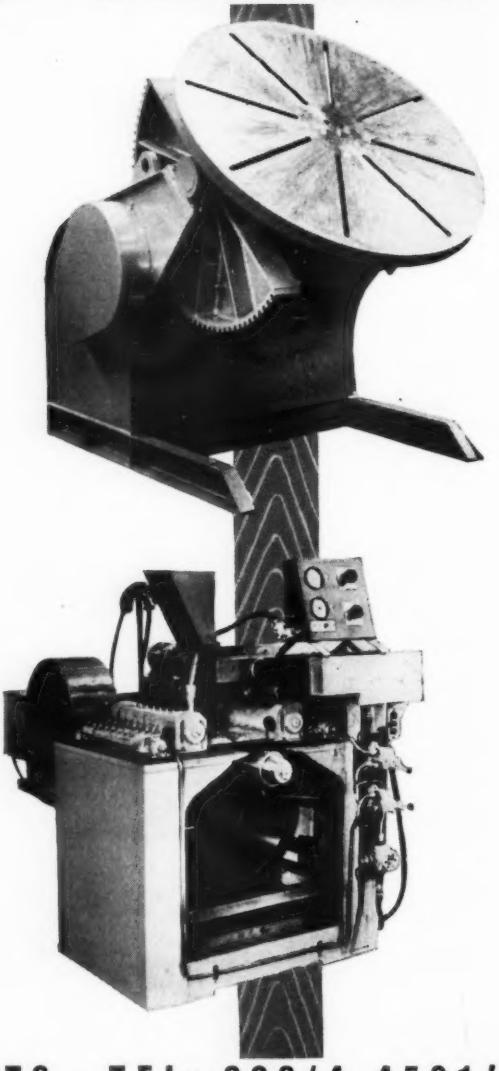
Tick **No 43** on reply card for further details

FIRST IN THE FIELD — STILL IN THE LEAD

★ AUTOMATIC & HAND WELDING UNITS ★ POSITIONING EQUIPMENT
★ WIRE AND FLUXES ★ ELECTRODES & ACCESSORIES
★ AFTER-SALES SERVICE



Complete Welding Installations by LINCOLN



For HIGH-SPEED production welding whether manual or automatic in application, LINCOLN offer a complete range of arc welding equipment and work handling fixtures, each installation being designed in close co-operation with your own engineering staff to ensure that it is individually fitted to your requirements.

Shown here is (above) a typical installation for pressure vessel and similar work incorporating the LINCOLN L.R.C. Revolving Column and Retractable Boom, a Fully Automatic LINCOLNWELD B.10 Submerged Arc Welding Unit, and LINCOLN L.S.A.R. Self-Aligning variable speed Rotators.

On the right is the LINCOLN 150 L.V.P. Variable Speed Positioner with a load capacity of 7½ tons, which is particularly suitable for heavy plate fabrication using either automatic or hand welding techniques. Shown below right is a LINCOLN Seam Welding machine incorporating a LINCOLNWELD M.L.3. Remote Control Automatic Submerged Arc Welding Unit.

For information on how the LINCOLN Complete Welding Installation Service can help solve your production problem please write to:

The Automatic Division

LINCOLN ELECTRIC

COMPANY LIMITED

WELWYN GARDEN CITY · HERTS · TEL: 920/4 4581/5

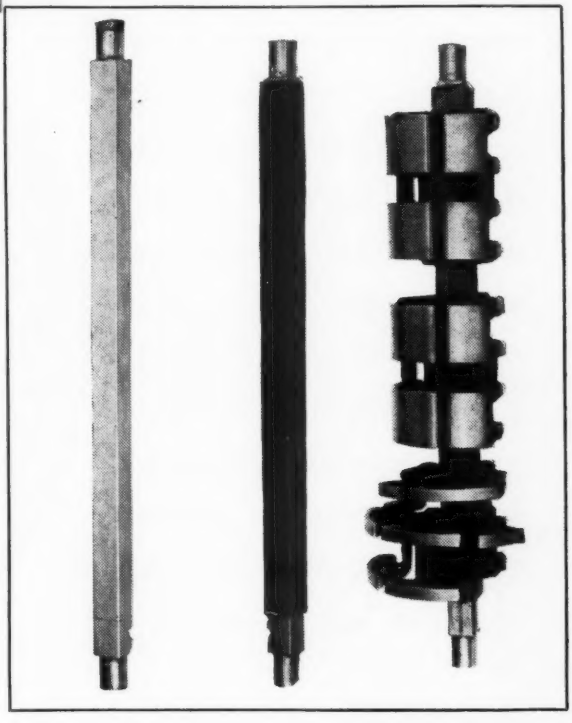
P.3

A proportion of the rolling stock of the London Transport Executive's railways is fitted with a heavy-duty reverser switch of the rotating drum type; the contacts are clamped to a square central shaft and insulated to withstand 600 volts. The contacts became loose, due to shrinkage of the insulating materials that were used in the past. A new, more robust material was needed, with high dimensional stability and insulating properties, good adhesion and the ability to withstand the compressive load of the clamped contacts.

FOUND:

Epikote Resin 828

The reverser shafts are now insulated with glass cloth impregnated with Epikote Resins 828 plus a hot-setting curing agent. The insulated shafts are pressed between angle formers to ensure dimensional inter-changeability. Oven-curing follows. This form of insulation has proved most successful under severe service conditions, and, as a result, many hundreds of reverser shafts have been modified in the London Transport Executive's workshops. **Epikote Resins help in many ways to make better products. Have you explored their possibilities yet — for the improvement of existing products or the development of new ones?**



EPIKOTE EPOXY RESINS

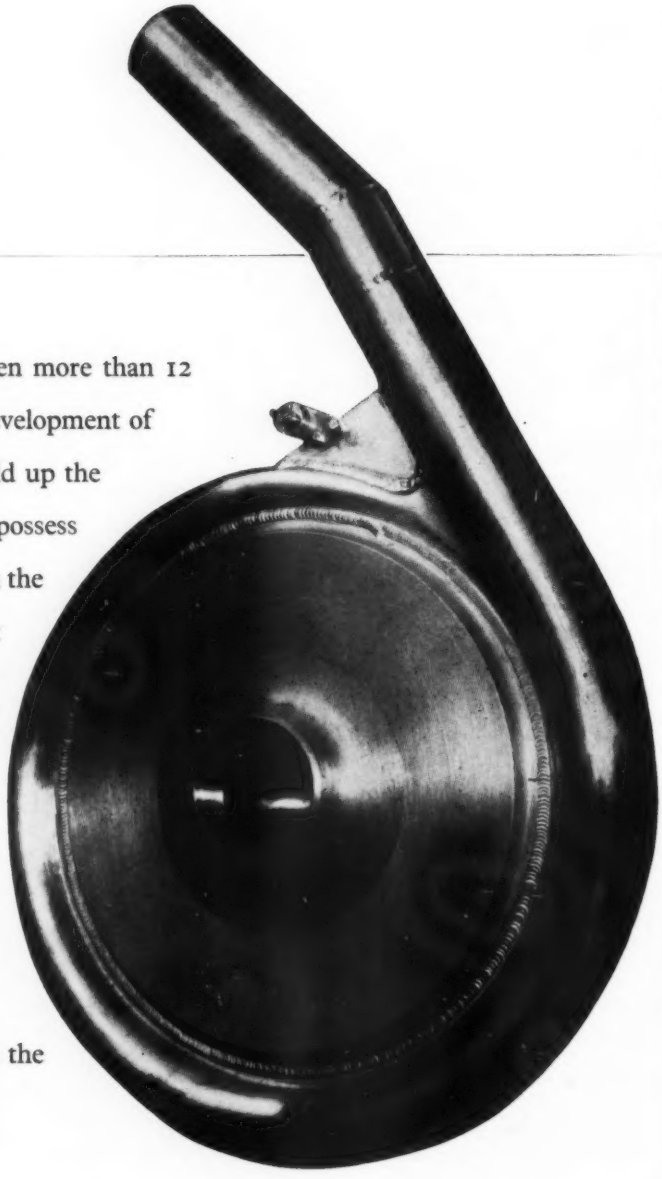
solve many production problems

SHELL CHEMICAL COMPANY LIMITED *In association with Petrochemicals Limited and Styrene Products Limited.*
Divisional Offices: LONDON: 105-9, Strand, W.C.2. Tel: TEMple Bar 4455. MANCHESTER: 144-6, Deansgate 3. Tel: Deansgate 2411.
BIRMINGHAM: 14-20, Corporation Street, 2. Tel: Midland 6954. GLASGOW: 124, St. Vincent Street, C.2. Tel: Central 9561.
BELFAST: 16-20, Rosemary Street. Tel: Belfast 26094. DUBLIN: 33-34, Westmoreland Street, Dublin. Tel: Dublin 72114.

SS 25

"EPIKOTE" is a Registered Trade Mark.

Shaping the Future



Skill doesn't come easily. It has taken more than 12 years of close association with the development of Atomic Energy for Marstons to build up the specialized technical knowledge they possess in this field. Marston Excelsior, from the start, have been among the foremost suppliers of specialized equipment to the U.K.A.E.A. — plate type fuel elements for the research reactors Dido, Lido, and Dimple; gas coolers for Calder Hall, equipment of various kinds for ancillary plants. It is this past experience that is helping Marstons to shape the future with such precision.

MARSTON EXCELSIOR LIMITED

ICI **Fordhouses, Wolverhampton**

(A subsidiary of Imperial Chemical Industries Limited)

INVOLUTE COMPRESSOR CASING

(approximate diameter 30″, overall thickness 5″) made in two half-pressings from Kynal P5, Argon Arc welded. In the centre, fully machined vanes made from aluminium castings are sandwiched between the centre plates.

MAR 234

DRAKELOW 'B'
(1-120 Mw Reheat units)

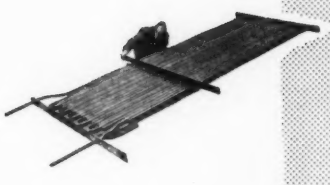
AGECROFT 'B'
(2-120 Mw Reheat units)

HIGH MARNHAM
(5-200 Mw Reheat units)

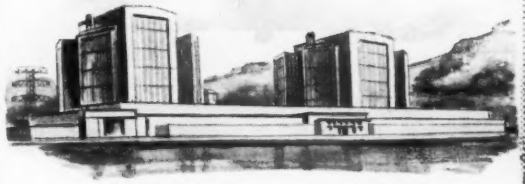
2—275 Mw REHEAT UNITS
and
1—550 Mw REHEAT UNITS

which represent the ultimate expression in the development, research, manufacturing and field experience with steam superheaters is brought to the Nuclear field through

HUNTERSTON *



* *Checking the precision level of a special Superheater element as supplied to Hunterston.*



The SUPERHEATER COMPANY LTD
97 TOTTENHAM COURT ROAD, LONDON, W1

the authority on superheated steam

Tick **No 47** on reply card for further details

FOR THE CHAPELCROSS REACTORS

Whessoe Ltd. chose Darlington Insulation

Nuclear engineering cannot tolerate faulty design or ill chosen materials. Every inch of a plant that houses such tremendous energy has to be designed and constructed to highly critical specifications. That is why such contracts go only to the cream of industry.

For this reason we at The Darlington Insulation Co. Ltd. are proud to have been selected by Whessoe Ltd. to insulate the reactors at Chapelcross ★

From Calder Hall on, The Darlington Insulation Co. Ltd. has been associated with most of the nuclear power stations completed and building in the United Kingdom, and we can fairly claim to be the world's most experienced nuclear power station insulation engineers.
In more everyday fields of heat, cold and sound insulation our experience is even greater—and it is entirely at your service. Simply write to

THE DARLINGTON INSULATION COMPANY LIMITED

A MEMBER OF THE DARLINGTON GROUP OF COMPANIES

38 Great North Road, Newcastle upon Tyne 2

or telephone Newcastle 23666

Branches at London, Birmingham, Bolton, Bristol, Cardiff, Glasgow, Leicester and Sheffield H16

★ *The insulating materials selected were, naturally, Metadextramite and Darlington 85% Magnesia made by The Chemical & Insulating Co. Ltd.—another member of The Darlington Group*

Tick **No 49** on reply card for further details

WESTON

MOVING COIL

RELAYS

The simplicity and reliability of relay control for a wide variety of applications has led to the ever increasing use of Weston Moving Coil Relays. Let us have a note of your relay problems and we will be pleased to advise on the most suitable model for any set of conditions. Enquiries should, if possible, be accompanied by full particulars of both control and local circuits.

Illustrated is the Model S170. Other types include the Model S124, a magnetic contact relay which operates with a minimum power input of 0.004 microwatt and the Model S115, a miniature relay, which functions as an "on-off" switching relay.

SANGAMO WESTON LIMITED
ENFIELD · MIDDLESEX
Tel: ENField 3434 (6 lines) & 1242 (6 lines) Grams: Sanwest, Enfield

Scottish Factory: Port Glasgow, Renfrewshire, Port Glasgow 41151
Branches: London, CHAncery 4971 Glasgow, Central 6208 · Manchester, Central 7904 Newcastle-upon-Tyne, Newcastle 26867 Leeds, Leeds 30867 · Liverpool, Central 0231 Wolverhampton, Wolverhampton 21912 · Nottingham, Nottingham 42403 Bristol, Bristol 21781 Southampton, Southampton 23328.

SW/67

Any Questions

What is a charge pan? a carousel? a rabbit tube? a coffin? a mortuary hole? What methods are used for cleaning up gas in the cooling circuits of British power reactors? Would a device used for fetching toys out of a crowded shop window have any applications in atomic energy? Would a new type of thermal insulation be any use in pressure vessel lagging? How much uranium ore is needed to make a complete fuel charge for Calder Hall? Where can I get reactor simulators? liquid metal pumps? boron-steel alloys? Who made the power-operated doors at the AEA's Capenhurst plant—we want some like them? Can platinum be welded to uranium? How can we adapt our air blowers to reactor coolant duties?

Looking back through our records we find these are just a few typical questions we've been asked over the last year or so. Finding answers was not always easy but by dint of much probing we were able to do this. We're also sometimes called upon to advise rather than provide information. For example a firm recently asked us whether advertising valve and gland seals suitable for effluent disposal lines would be a better proposition at the present time than high pressure filters and pumps.

Of course we're not omniscient and we've been stumped on more than one occasion. Sometimes it's national security, more often it's commercial security, often it's just that no one knows the answer. For example we've had searching questions on Calder Hall, demands for intimate details of the commercial power stations and a request for a frank opinion on the feasibility of a proposed thermonuclear fusion device.

These questions tie up a lot of staff time but we're glad to handle them because we believe our duty to the reader goes beyond simply producing him a magazine.

We do not guarantee to answer all or any questions but if they're genuine and we think the answer's obtainable, we'll try.

LIGHT ALLOYS in nuclear research and development

Birmetals

Light alloys in all wrought forms

The large scale production of the special magnesium alloy used to make the fuel element cans for Calder Hall was the result of collaborative experimental work by Birmetals Limited and the United Kingdom Atomic Energy Authority.

Similar collaboration between Birmetals, the U.K.A.E.A. and the commercial constructors of nuclear power plants is ensuring continued development in this and other allied metallurgical fields.

BIRMETALS LIMITED · WOODGATE WORKS · BIRMINGHAM 32

BM 221

Tick No 51 on reply card for further details

STAINLESS STEEL

SHEETS · BARS · TUBES
STRIPS & BLANKS · also
PROFILE CUTTING &
SHEET POLISHING

WE WILL PROFILE ANY SHAPE

COX AND DANKS
LIMITED
SCAPA HOUSE · PARK ROYAL RD.
LONDON N.W.10

The future for food

SIR: A great deal of ballyhoo has been written about food irradiation over the last few years and it was refreshing to read the rather sobering account you gave last month of the FAO symposium at Harwell. Nevertheless, the fact that FAO has taken up the subject in such a big way seems to indicate that it has some considerable future. Furthermore, in an article by Norman W. Desrosier, Director of Food Radiation Protection Division of the Quartermaster Food and Container Institute for the Armed Forces at Chicago, published in the proceedings of the OEEC's Conference held in Paris last July, he states

> 'The first date for trial evaluation of an item of food which has been radiostabilized is in the autumn of 1960. At that date, if no adverse effects are noted —and none have been to date—a radiation stabilized food will be cleared as suitable for human consumption in the United States of America.'

I think on the whole you gave a well-balanced review of the situation but let us by no means write off this subject.

*London, W*11 STEPHEN F. WALKER

The facts of life

SIR: There is an old quip about the pot calling the kettle black which Mr Stretch's article in your December issue brings to mind. In fact, our large nationalized undertakings work on an economic arrangement which does not square with the facts of life which commerce has to face. It is no use Mr Stretch chiding Sir Christopher Hinton about low capital charges unless he is prepared to face the same charge. Nor is it any use talking about the actual cost of coal and nuclear fuel unless everything is thrown in for each, including research and development, losses and the rest. Nor is it any use comparing cost per unit sent out when it is cost to the consumer which counts, which brings in the whole question of transport and distribution. Unfortunately, we hardly ever compare like with like and Stretch is no exception in this.

If we really compare like with like on a commercially competitive basis we may find that the choice is not between whether we should build nuclear or coal-fired power stations but includes other things like private generation, power plus process heat, increased capital expenditure in industry and the home to improve fuel use and increase process efficiency and heat recovery, the building of plants in complementary power and heat complexes, and so on.

Far from carrying out the analysis 'more critically,' Stretch seems to throw out yet another smoke screen when he examines costs. Quite obviously it is nonsense to divorce technical advance from type, duty, size and quantity when all of these hang on technical advance. No one who has really had to face competition from other equipment would fall into this trap. Nor is there any one figure to apply to rising costs because one has to separate out labour, material, and capital before one can examine each one logically and start the argument. This comes out most clearly as nonsense when talking of size (I presume Stretch means output) when we find that 'the

continued on p 55

STEEL, PEECH & TOZER

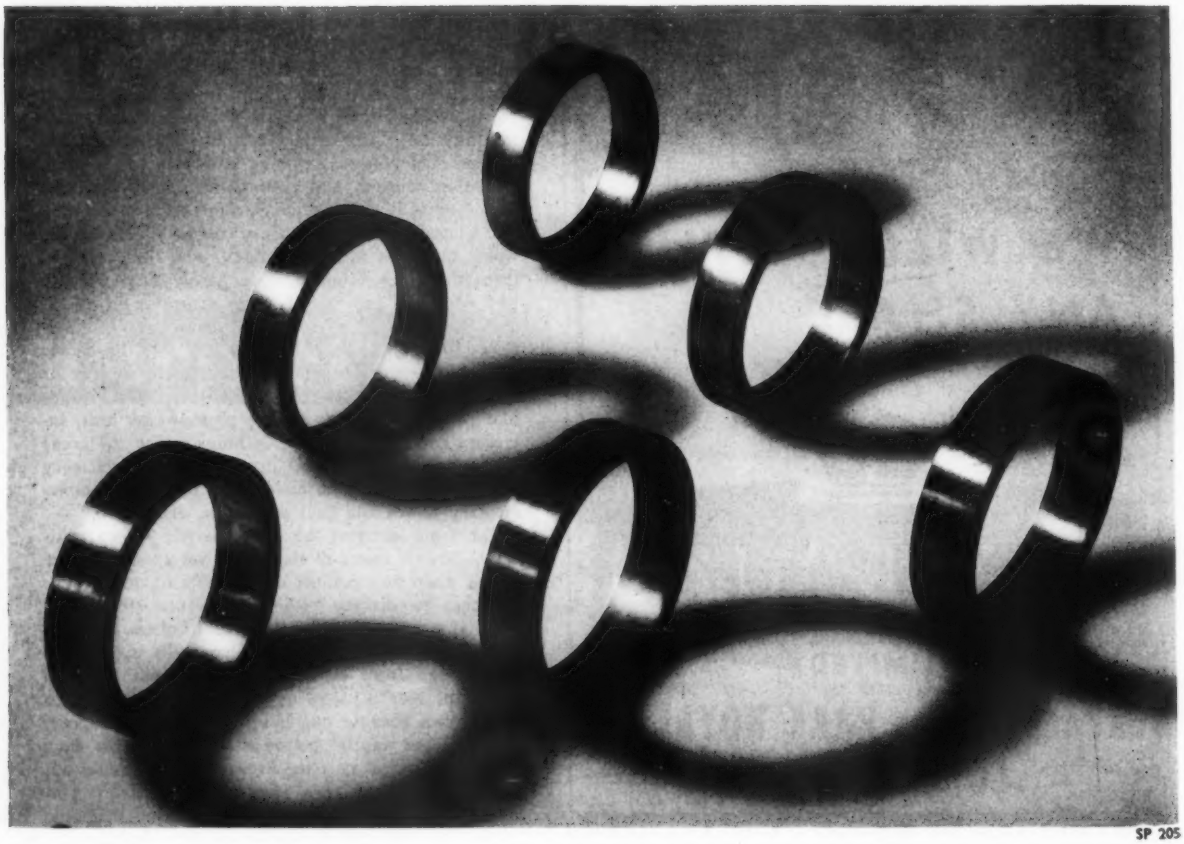
A Branch of The United Steel Companies Limited

THE ICKLES, ROTHERHAM, YORKSHIRE

THE UNITED STEEL COMPANIES LTD

FORGED AND ROLLED STEEL RINGS

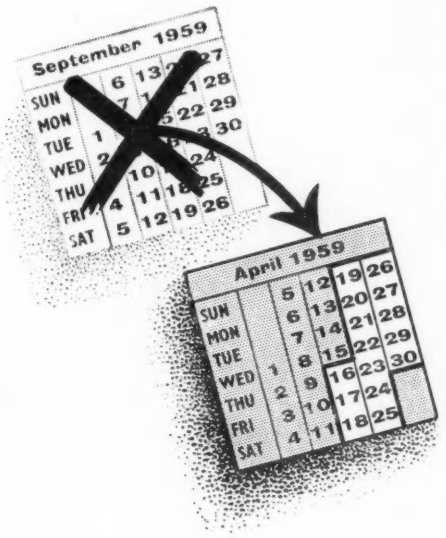
Rings in all sizes from 2″ to approximately 96″ in diameter and up to one ton in weight are produced by rolling, hand forging or upset forging, depending upon size. Profile sections can be rolled if ordered in quantity. A wide range of qualities from mild steel to highly alloyed steels may be specified.



SP 205

Tick No 53 on reply card for further details

A Popular Change of Date



ENGINEERING marine, welding & nuclear energy EXHIBITION

The largest event of its kind in the world

If you are an Engineer - of whatever kind - this is YOUR Exhibition. In Olympia on a floor space of over a quarter of a million square feet, over 500 of the world's leading manufacturers will show their most up-to-date equipment for your benefit. This Exhibition has been internationally famous for over 50 years. It occurs only once every two years. Previously it has been held in September, but in 1959 for the first time it has been possible to meet the popular demand for the Exhibition to be staged in the Spring of the year.

OLYMPIA · LONDON

APRIL 16th-30th, 1959

Opening hours: April 27th, 28th, 29th—10 a.m. to 8 p.m.
ALL OTHER DAYS — 10 a.m. to 6 p.m. CLOSED SUNDAYS

ORGANISED BY F. W. BRIDGES & SONS LTD
Grand Buildings, Trafalgar Square, London, W.C.2.
Tel: Whitehall 0568. 5 lines.

SIR!

continued from p 53

entire gain indicated can be attributed to the steady increase in size.' One has only to take a look at the oil engines produced say towards the end of the last century or even before the war to realize how far we have come. The main fallacy stems, I suppose, from Hinton since what the argument really should be about is overall operating cost which takes into account the things that Stretch mentions such as reliability, safety, supervision and so on. It seems probable that we started on the wrong argument in order to give economic blessing to a policy, to build nuclear power stations which was really undertaken to fill a fuel gap. We then were subjected to a rush of economic proofs, such as Pask and Duckworth's 1955 paper to the BNEC, which set out to prove the whole thing to three decimals of a penny. Where the crystal ball seems to have really come unstuck is on whether there is going to be a gap within a reasonable time. After all, the post war situation could not be expected to go on for ever. Possibly the error lies in using doubling times and log paper.

Slough, Bucks M. J. KEMPER

Fuel licences

SIR: I was most interested to read in your account of Sir William Cook's speech to the European Atlantic Group (*They said* last month) that the UKAEA is apparently intending to set up for large-scale production of fuel elements. It is, of course, obvious that the way to cheapen fuel is to set up mass production lines and for the British home programme of nuclear power it is advantageous if all the fuel comes from the same source.

For many countries considering nuclear power plans, however, one of the attractions of the British type of reactor is that it is based on natural uranium fuel and this they believe they can produce themselves once they have the necessary knowledge and experience. Mr Fletcher stated that Britain was prepared to grant normal commercial licences at the appropriate time for fuel fabrication. So far I have not heard of any such licences being issued and I wonder if any have been applied for.

Bern, Switzerland W. HANAU

Mounted drawings

SIR: In *Cross Section* of the November issue, mention was made of copies of your coloured drawings being mounted between plastic and hardboard. I should like a copy of the Chapelcross drawing so treated and would be grateful if you could tell me how to order one and what the cost will be.

Chapelcross Works, Annan D. E. CHANDLER

▶ *The cost of the drawings, which measure about 3 ft by 2 ft, is £3 3s 0d including delivery in the U.K. Orders to* NUCLEAR POWER. *Ed.*

Prior splitting

SIR: The letter 'Splitting the infinitive' which appeared in your December 1958 issue, was published in the *News Chronicle* approximately ten years ago.

That paper stated that 'It originally appeared in *The Tennessee Valley Engineer* and has been reprinted elsewhere in the United States.'

*London, SW*16 D. A. BROWN

'COMPATIBILITY'

Like the animals in the Ark, metals in a nuclear reactor have to dwell side by side in amity. That's compatibility.

The canning material—aluminium, magnesium or zirconium perhaps—must exist peaceably and for a calculable time in intimate contact with another metal, uranium. In metallurgical terms, compatibility must be guaranteed.

But that alone is not enough. The same metal must completely protect the fuel from the hot liquid or gas which surrounds it and, therefore, be corrosion resistant.

Metallurgists at I.C.I. Metals Division were specialising in corrosion technology long before the coming of nuclear engineering. The Division has acquired unique experience in developing metals and alloys to withstand specific operating conditions, however arduous. That is one reason why so many vital contributions to the progress of nuclear engineering have been made by I.C.I. Metals Division.

ICI METALS DIVISION

IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1

PR2a

Nuclear Power
REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION
FEBRUARY 1959 VOLUME 4 NUMBER 34

Partnership in Europe

The sense of urgency with which the United States is tackling the European market is well illustrated by the setting up of the US-Euratom Joint Research and Development Board—right inside the Euratom headquarters in Brussels—before the agreement has even come into force. While the Americans get the machinery ready to implement a 1000 MW programme and the Board announces its readiness to receive development proposals from interested companies right away, Britain dithers uneasily on the sidelines.

Politically, the Government have never been much enamoured with Les Six and have chosen instead to press for the Free Trade Area. It would be out of place here to go into the complex political issues involved but it is an inescapable fact that the Free Trade Area idea is now a dead letter despite Mr Maudling's impassioned advocacy and its demise has left in Britain a yawning vacuum. Actual membership of Euratom is probably contingent upon membership of the Economic Community and as such is impossible for us, at least in the foreseeable future. But the Americans have proved to the hilt that this is not at all necessary: given the will and determination much of its advantages can be enjoyed without political commitment. The projected UK-Euratom agreement is an attempt to do this, but compared with the US agreement it hardly begins to look serious: in its present form it cannot and will not satisfy industry.

Euratom and the Nuclear Common Market are here to stay whether we like it or not and the six countries form a compact, easily accessible area which could form an invaluable outlet for the British nuclear industry. That they want to do business with us there is no doubt. Louis Armand, writing in this magazine only last month made it quite clear that there is still a place in the Euratom picture for British reactors, but we don't have all the time in the world and to claim this place we shall have to move fast. One has only to glance at the French and German programmes to see that Continental engineers and scientists already know plenty about gas-cooled reactors: France has construction and operating experience and industrial groups are ready to go ahead and build reactors for any willing buyer; German concerns are designing full-scale stations. Every day that passes must mean that we have less to teach.

The emphasis must therefore be on co-operation—not 'let us sell you a British reactor' but 'let us help you build one.' The Americans understand this fully and the leading reactor companies are already well established with full partnership associates in most European countries. The joint research and development programme is clearly the cement that welds these uncoordinated enterprises into an integrated economic drive which in its train will bring in the whole US nuclear ancillary industry.

We cannot hope to match this US effort in sheer size but we certainly can and must in quality. This will need from the Government not only a new political attitude to Euratom but also a new outlook in the British nuclear industry which so far, with the exception of the group building the Latina station, does not seem to appreciate the fact that the mere doling out of subcontracts is now not enough.

SOLARTRON

present a range of fine oscilloscopes for 1959

Continuous basic development and active research into customers' requirements ensure that there is always a Solartron precision-engineered oscilloscope available for your specific application.

A brief look at the nine basic specifications below will help you to plan your visual analysis instrumentation. From the special CD 715 for monitoring of power supplies to the latest Measuring Oscilloscope—the CD 643.2—each instrument represents the finest value in oscilloscopes obtainable today.

The CD 643.2 Measuring Oscilloscope (illustrated) is the most accurate measuring 'scope in quantity production. With a constant bandwidth of D.C. to 12 Mc/s and an effective timebase ratio of 100 million to one, the CD 643.2 has precision decade measurement facilities on both 'X' and 'Y' axes. On the 'X' axis "bright-up" markers for pulse work—and for lower frequencies a brightening pedestal of accurately controlled duration; whilst on the 'Y' axis precision switching of a reference voltage source enables signal nulling to be easily accomplished and amplitude measured directly off the controls, both to an accuracy within 2%.

	General Purpose Oscilloscope CD 513·2	Pulse & Radar Monitor Oscilloscope CD 518	General Purpose Oscilloscope CD 52382	Servo Oscilloscope AD 557	Pulse & Radar Monitor Oscilloscope CD 568	Measuring Oscilloscope CD 643·2	Double-Beam Oscilloscope CD 71182	Power Supply Monitor Oscilloscope CD 715	Constant Bandwidth Oscilloscope CD 814·2
Services No:	—	Mod. Version of CT 316	CT 386A	—	Mod. Version of CT 316	CT 380	CT 414	Admiralty Mk. 29 TU	—
Bandwidth (3db):	Max: D.C.—10 Mc/s.	Max: D.C.—5 Mc/s.	Max: D.C.—10 Mc/s.	Max: D.C.—1 Mc/s.	Max: D.C.—5 Mc/s.	Constant: D.C.—12 Mc/s.	Max: D.C.—7 Mc/s.	Max: D.C.—20 Kc/s.	Constant: 0·9 c/s—9 Mc/s.
Sensitivity:	1mV/cm.—10 V/cm.	0·4 V/cm.—10 V/cm.	1mV/cm.—10 mV/cm.	3 mV/cm.—100 V/cm.	0·4 V/cm.—10 V/cm.	100 mV/cm.—60 V/cm.	3 mV/cm.—100 V/cm.	10 mV/cm.—10 V/cm.	30 mV/cm.—30V/cm.
'Y' Calibration:	Cal. Sensitivity Acc: 10%	Shift Meter Acc: 3%	Cal. Sensitivity Acc: 10%	Cal. Shift Acc: 5%	Shift Meter Acc: 3%	Cal. Shift Acc: 2%	Cal. Shift Acc. 5%	Special Facilities	Comparison A.C. Acc: 5%
'X' Calibration:	Cal. Adjustment Acc: 10%	'Pips' and Sinewave Acc: 2% & 1%	Cal. Adjustment Acc: 10%	Cal: Adjustment Acc: 10%	Sinewave Acc: 1%	'Pips' and Bright-up Acc: 2%	Cal. Adjustment Acc: 5%	Special Facilities	Brilliance Mod. Acc: 5%
Sweep Velocity:	10 cm./Sec—10 cm./μSec.	0·1 cm/m Sec—10 cm/μ Sec.	1 cm/Sec.—10 cm./μ Sec.	1 cm./Sec.—1 cm./μ Sec.	0·1 cm./m Sec—10 cm./μ Sec.	10 cm./Sec.—10 cm./μ Sec.	0·33 cm./Sec.—3.3 cm./μ Sec.	1 cm./Sec.—100 cm./Sec.	0·1 cm./m Sec.—2 cm./μ Sec.
'X' Expansion:	× 0·5, × 1·0, × 2·0, × 5·0.	—	× 0·5, × 1·0, × 2·0, × 5·0.	Variable up to × 10	—	Variable up to × 100	Variable up to × 10	× 0·05, × 0·1, ×0·2,0·5,×1·0.	Variable up to × 10
Dimensions:	16½" × 10" × 22" deep.	12" × 9" × 18" deep.	16½" × 10" × 22" deep.	16½" × 10" × 22" deep.	12" × 9" × 18" deep.	20" × 14¾" × 27½" deep.	16¾" × 13" × 27½" deep.	14" × 10" × 20" deep.	14½" × 10½" × 19½" deep.
Weight:	70 lb.	40 lb.	70 lb.	70 lb.	40 lb.	140 lb.	116 lb.	47 lb.	43 lb.
Price:	**£235**	**£235**	**£275**	**£285**	**£220**	**£490**	**£390**	**£460**	**£145**

Also available shortly—the new Solartron Infinite Persistence Oscilloscope Type QD 910

Why not write or call us now for a demonstration of any of the nine models listed above ?
Specialist instrument engineers are immediately available to assist you, whatever your problem or field of application.

THE SOLARTRON ELECTRONIC GROUP LIMITED

THAMES DITTON • SURREY • TELEPHONE: EMERBROOK 5522 • CABLES: SOLARTRON, THAMES DITTON

Worldview

the month in atomic energy

Tear drop for Dreadnought

Differences between Britain's nuclear submarine *Dreadnought* and the American *Skipjack* type seem to be narrowing towards vanishing point, with the sole exception that *Dreadnought* has not been designed to carry missiles. The Admiralty has now announced that the hull design is based on the US *Albacore* form which has a 'tear drop' shape to give better underwater, at the expense of surface, streamlining. While no decision has been made on the proposed American pressurized water reactor plant negotiations are still continuing under the terms of the Anglo-US agreement of last July for atomic energy cooperation. Those who believe that the UK should make use of the work already done and develop its own propulsion plant are still keeping up a rearguard action.

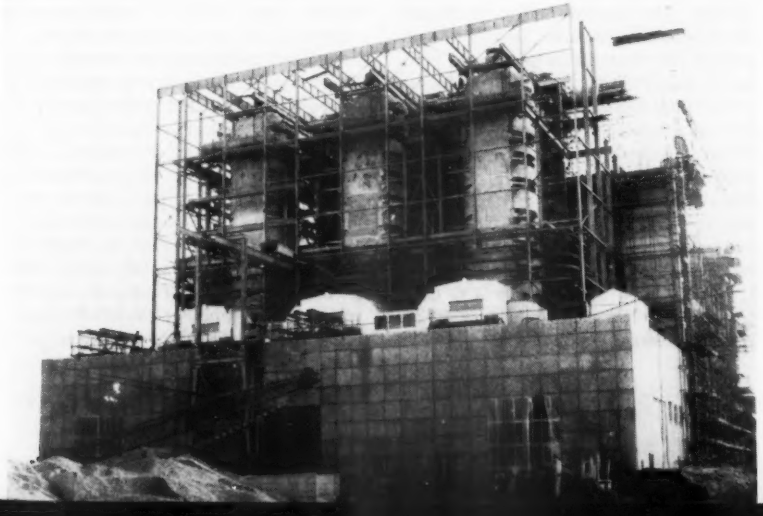
A new floating dock, the AFD-59 is being built at the Portsmouth naval dockyard. This dock will initially be used at the Vickers Armstrong's yard at Barrow-in-Furness during the construction of the hull. Subsequently it will provide repair facilities for the latest type submarines as well as being able to accommodate destroyers and frigates. The AFD-59, for which Clark and Standfield Ltd are the Admiralty's design agents, will be fully equipped to carry out routine maintenance and repairs of ships docked and provide accommodation and facilities for the crews of the dock and the ships in dock. It is anticipated that future British atomic submarine activities will be revealed soon in a Defence White Paper.

300 ideas for sale

The number of Atomic Energy Authority inventions available for industrial use has now exceeded 300, according to an official list just prepared. Only recently released for use in industry generally they are reliably estimated to be already engendering business at the rate of hundreds of thousands of pounds a year. Under an agreement between the governments of the UK, the US and Canada, several hundred American and Canadian atomic energy inventions have been assigned to the Authority and many of these are also available for general use.

Although originally developed for atomic energy purposes they have general applications in the engineering, chemical, metallurgical, electronic and instrument fields; one example of this is the Spraypak method of distillation evolved by Harwell which, initially designed to assist in the production of heavy water has found other uses, and licences have been granted for its employment in the UK and elsewhere. When inventions are freely available, the Authority are willing to grant licences to suitable manufacturers in both the UK and overseas countries. Non-exclusive rights are normally given but in exceptional circumstances, such as a development needing a large amount of capital—or one in which no one else is interested—a sole licence may be granted. The Authority say they are also prepared, in the case of a patent still in the provisional stage, to consider entering into an agreement to grant a licence and thus give the firm concerned the opportunity of beginning manufacture and sales before the grant of letters patent.

BRADWELL All six boilers are now in place on the 150 MW No 1 reactor. The Nuclear Power Plant Company hopes to have it in operation by June 1960



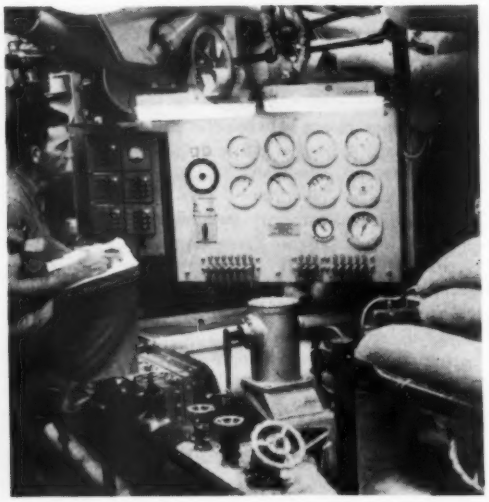
DUTCH DEGREE FOR COCKCROFT Sir John receives the citation of an honorary degree from Professor R. Kronig of Delft University during the celebration of its 117th anniversary in January

AEA moves in on standards

The Atomic Energy Authority has joined the Engineering Equipment Users Association. Formed ten years ago to push the users point of view on engineering standards, the Association now has representatives on over 200 British Standards Institute Committees, and its own 28 technical panels (18 mechanical, 2 civil and 8 electrical) produce a steady stream of technical handbooks and codes of practice. It has had some success in changing the situation prevailing after the war when standards tended to be tailored to manufacturers' rather than users' needs; many BSI standards since have been actually initiated by the Association. The Authority decided to apply for associate

Triton prototype undergoes tests

The land based propulsion plant for the world's largest nuclear submarine is now working on the test site of Knolls Atomic Power Laboratory at West Milton, New York. Inside the hull section (bottom left) technicians check the General Electric turbine generator (left) which supplies auxiliary power, and the controls (bottom right) for the pressurized water reactor. This produces steam for driving a turbine to simulate operating conditions. A water wheel dissipates energy produced for simulated submarine manoeuvres. In addition to making the prototype, KAP —operated by GE for the Atomic Energy Commission—is developing the actual twin-reactor plant for the 5450 ton, SM95 Triton, due for completion by the end of this year



membership in the first instance, which gives it all the technical advantages of full membership but little voice in policy decisions—of the ten Council members eight are appointed by the full members and only two by the associates. However, it may seek full membership in a year or two. Full members are: Albright and Wilson, Courtaulds, The Distillers Co, Dunlop Rubber Co, Imperial Chemical Industries, Monsanto Chemicals, Shell Petroleum and Unilever. The associate members are: A. Boake Roberts & Co, The British Transport Commission, The Metal Box Co, The National Coal Board, United Glass Bottle Manufacturers and United Steel.

FRANCE

First Wigner release succeeds

The first annealing of the 5 MW G-1 reactor to release part of the Wigner energy stored in the graphite was carried out at Marcoule recently in the presence of Commissariat à l'Energie Atomique officials and British observers invited for the occasion. The whole operation, which was successful if not entirely according to plan, lasted 25 hours and results are now being evaluated.

Change of plan

The reactor, which is cooled by once-through air, consists of a horizontal cylindrical pile divided into two by a cooling air manifold on the central vertical plane. For the experiment it was partly discharged, channels being emptied on a radius of 3 metres, and about 80 thermocouples were used to measure graphite surface temperature. Original plans for the experiment envisaged three stages: **1.** Preheating with air entering the reactor at about 90°C until thermal equilibrium was established in the pile, **2.** heating with air at about 130°C, **3.** heating with 180°C air to trigger off the Wigner release. In fact the operation did not quite follow this scheme. The first stage had to be maintained for about 9 hours—longer than anticipated —and temperatures in the lower and upper halves of the reactor showed important differences. The second heating revealed a tendency for the temperature of the two halves to equalize, but the behaviour of the pile was peculiar, and the heating was stopped when an inlet air temperature of only 110°C had been reached. The third stage with inlet air reaching 150°C proved successful after some difficulties and a Wigner energy release commenced. Over a period of 7 hours a volume of graphite about 2·5 metres dia and 2 metres long on each side of the central vent was affected and maximum graphite temperatures measured reached 280°C.

GERMANY

Third 100 MW stays at home

Following the two design study contracts for a 100 MW plant in North Germany, which were awarded to the German Babcock and Wilcox and the AEG concern (*Worldview* last month), Siemens-Schuckert has received one for a 100 MW plant in Bavaria. It was given by the Gesellschaft für die Entwicklung der Atomkraft im Bayern, a partly state-owned electricity supply group. The design is for a natural uranium-fuelled heavy water-moderated reactor and will take about three years to complete.

HUNGARY

OK from Moscow?

During a recent tour of Hungarian research establishments, Professor D. I. Blohinchev, director of the USSR's United Atomic Research Institute at Dubna, stressed the necessity of closer coordination in atomic research between socialist countries. Lack of funds appears to be the main restriction on the Hungarian activities, but all the same the Atomic Physics Research Institute is working on neutron physics applications in reactor building, and the Central Physical Research Institute is specializing in construction of instruments for nuclear physics research and automated processes relative to the study of the behaviour of high speed particles. This institute is also engaged on the theoretical examination of the nature of light, whilst the Debrecen nuclear research institute of the Academy of Sciences is working on the heavy element atoms. Although there are already eleven Hungarian scientists working at Dubna it has been suggested that to overcome the lack of facilities and prevent excessive economic strain, Hungarian scientists, engineers and workers submit their reports to the USSR's Institute and exchange ideas with them.

—— SOUTH KOREA ——

Help from Washington

The first steps have been taken towards establishing a National Atomic Research Institute. Total cost is estimated at over $M1 and the United States is to contribute $350,000 towards the cost of the reactor project. In the early stages the General Dynamics Corporation will act as consultants in establishing the institute requirements and procuring the scientific equipment. The Korean government will allocate scientists, engineers and technicians to work in General Atomics' John Jay Hopkins Laboratory in preparation for staffing the Korean Institute. This establishment will be located at Paktai-re seventeen miles south of Seoul. The institute will be based on an above-ground TRIGA Mark II—which, in addition to the standard irradiation, isotope-production and training facilities, will include neutron beam ports and thermal column.

——UNITED STATES——

Drive for cheaper power

Proposals towards the cheaper and wider civil use of nuclear fuel have been given increased importance in the present AEC programme—with emphasis on the use of plutonium. To encourage the employment of uranium-233 and plutonium as fuels, the Commission have established charges at $15 and $12 per gram respectively and it hopes that this will lead to development of the materials as power sources on a par with U-235. Foreign governments already having agreements for cooperation with the US will be able to get the materials at the same prices.

Interest in fuel cycle development is not confined to the AEC; already 107 proposals have been received from industry to participate in the programme, which will include the fabrication, use and removal of fuel elements together with re-enrichment and re-use.

Supporting this 'cheaper' fuel, attention is given to fast breeder reactors and eight proposals have been submitted for the Commission's contract of a plutonium oxide-uranium oxide fuel cycle reactor which will take at least eighteen months to complete.

Fast breeder projects The fast breeder programme already includes the two experimental reactors at the NRTS Idaho and the Commission is giving research and development assistance to PRDC's Enrico Fermi at Monroe. The construction permit for the PRDC project has been confirmed and work is well forward on site with the three intermediate heat exchangers installed. A licence to operate will not be issued at this stage. A complete Hazards Summary Report has to be submitted and the Commission's approval of the design in its final form will have to be obtained before an operating licence will be granted.

After receiving 86 proposals from 32 architect-engineering companies AEC are now negotiating studies with three companies associated with Combustion Engineering Inc (pressurized water), GEC (boiling water), and Atomics International (organic cooled). Here again the purpose of the three studies is to ascertain the most economical power station design for each of the three.

Homogeneous project dies

The homogeneous reactor — already abandoned by Britain—has suffered a severe setback in America with the decision by Westinghouse and the Pennsylvania Power and Light Co to drop their planned 70–150 MW project after 3½ years of research. The reactor, to have been built at Allenton, Pa, by 1963 under the AEC's Power Demonstration Reactor Programme, was the only firm proposal for a full scale plant in the US. Cost to the companies and the Commission would have been about $M108.

In a joint statement, officials of the companies stressed their belief that the concept holds 'bright promise' for the future, with its potentiality for conversion of thorium to fissionable material. 'However, the present facts indicate the necessity of further research and development work, including a prototype and operating experience, before a large-scale plant would seem to be warranted.' After indicating that no single insuperable problem had arisen, they declared it had been found necessary to face up to the 'multiple uncertainties that exist,' which 'have become increasingly critical in view of the project's time limitation.' Reaction to the decision was critical with several comments on the lines of Senator C. P. Anderson's who stated: 'I believe this project demonstrates the fallacy of expecting private industry to provide the technical direction and financing for construction of advanced reactor concepts. It may throw some light on current alternatives in the gas-cooled reactor field of (1) AEC construction under contract of a moderately advanced type, or (2) private construction of a more advanced type with AEC assistance on research and development. We may have to decide whether we should walk before we try to run. As a matter of national policy, I believe it is undesirable to permit the field of advanced atomic power concepts to be "staked out" as the private domain of industry. I have endorsed an expanded atomic power programme

Honoured in New Year List

Among the scientists, business men and industrialists receiving awards in the New Year Honours List published January 1 many are directly or indirectly concerned in the nuclear field. Those awards of interest to the industry are given below: **Knights Bachelor** Mr A. F. Burke, deputy chairman and managing director of De Havilland Aircraft Co Ltd; Maj-Gen C. A. L. Dunphie, managing director, Vickers Ltd; Mr J. W. Laing, president, John Laing & Son Ltd; Mr R. P. Linstead, rector, Imperial College: Mr K. J. Spencer, chief scientist, Ministry of Power. **K.C.B.** Mr P. D. Proctor, permanent secretary, Ministry of Power. **C.B.** Mr W. B. Littler, director-general, scientific research (munitions), Ministry of Supply. **C.B.E.** Mr W. A. S. Butement — chief scientist, Department of Supply (Australia); Mr M. Cook—chairman, metal division, Imperial Chemical Industries; Mr P. T. Fletcher, deputy managing director, UKAEA (IG), Risley; Mr L. T. Morton, joint managing director, Clarke Chapman & Co Ltd; Mr J. H. Reed, managing director, Ericsson Telephones; Mr J. McW. Storey, managing director, Dewrance & Co Ltd. **O.B.E.** P. W. Mummery, senior principal scientist, Reactor Div, AERE, Harwell. **M.B.E.** Mr F. S. Dennard, technician grade 1, AWRE, Aldermaston; Mr I. H. Hogg, senior research planning officer, Research and Development Branch, UKAEA (IG), Risley; Mr D. Sleath, chief draughtsman, instrument dept, Laurence Scott and Electromotors Ltd; Mr F. R. Warner, head of sales dept (contracts div) General Electric Co Ltd.

MUMMERY—O.B.E.

HOGG—M.B.E.

DENNARD—M.B.E.

in which the AEC would develop the advanced concepts, and private industry would sponsor "second and third" generation projects with increased government assistance.'

—INTERNATIONAL—

First U-bank in business

Japan is to get her 3000 kg of natural uranium from the International Atomic Energy Agency (*Worldview* Jan) at $35·50 a kg. Tenders varying between $54·34 (USA) and $34·00 (Belgium) a kg were received by the IAEA while the Canadian government, 'to expedite the Agency's activities,' offered to supply it free of charge on the understanding that it was sold at a price 'bearing a reasonable relationship to the current world price,' and it is this Canadian material which will be supplied to Japan. In announcing the decision on price, the IAEA director general Sterling Cole said it took into account the Agency's Statute which calls for the establishment of a scale of charges for materials which will just cover expenses. It is interesting to note that the agency has settled on a figure $4·5 a kg less than the $40 charged by the US in bilateral agreements.

IAEA plans five conferences

At the 1958 Atoms for Peace Conference in Geneva many delegates voiced the need for coordinating efforts, programmes and work in specialized fields. Following up these suggestions IAEA have announced that five scientific meetings on particular aspects of nuclear energy are to be held. The first will be a three-day seminar in Vienna, from February 25, on medical radioisotope scanning, at which some 45 experts will discuss the latest techniques and equipment. This meeting is arranged jointly by IAEA and the World Health Organization. In July nearly 80 experts will attend a seminar at Saclay, France, on the training of specialists. During September a six-day conference in Warsaw is scheduled on the application of large radiation sources in industry with special reference to chemical processes and three hundred delegates are expected to attend. Following this a meeting in Vienna in October will be held covering the standardization of radioisotopes, with about one hundred participants, mainly from national laboratories.

The final meeting of the series will be at Monaco in November. This will be a conference on the disposal of radioactive waste and is intended to supplement the IAEA panel of experts set up last October to study disposal in the sea.

SWITZERLAND The 600 ft dia 25,000 MeV proton synchrotron is taking shape at Meyrin, near Geneva. Under construction for the 12 member countries of the Conseil Européen pour la Recherche Nucléaire whose management buildings and laboratories can be seen in the background, it will be completed by December 1960

US, Euratom invite proposals

Moving fast, the US Atomic Energy Commission and Euratom have set up a Joint Research and Development Board at the Brussels headquarters of Euratom and announce that they are ready to receive proposals centred on reactors to be built under the joint 1000 MW programme. While statutory requirements for getting the agreement into force have not yet been completed proposals are being solicited at this time, says a joint announcement, 'in order to expedite the process of review and evaluation so that the research and development programme can be initiated promptly after the effective date of the agreement—probably mid February.' As stated in the agreement for cooperation, 'The programme will be aimed primarly at improving the performance of the reactors to be constructed and at lowering fuel cycle costs; it will also deal with plutonium recycling. Specific projects of interest to the Board include specialized fuel element test reactors, research on fuel element metallurgy and fabrication, moderator research and development, and reactor component engineering. Due to run for 10 years the programme will be financed by equal contributions from the AEC and Euratom. For the first five years the total funds available are expected to amount to about $M100 and capital for the second period may be about the same. It is planned that roughly half the money will be spent in the United States and half in Europe for research and development contracts and for experiments on the reactors to be built.

UNITED STATES One of the only two privately owned high power test reactors under construction in the US, the Westinghouse Testing Reactor at Waltz Mill, Pennsylvania, is almost complete. Like the General Electric GETR, it is a tank type. A gravity flow system will carry demineralized water from the 240 ft water tower (centre) to the 20 MWt reactor located in the 85 ft high cylindrical vapour container

We join everyone else in the nuclear world in regretting the death of Sir Claude Gibb, chairman of the Nuclear Power Plant Co, as a result of a heart attack after leaving a plane at Newark, New Jersey, on January 16.

WORLDBRIEFS

● **Austria** As recommended by the Austrian Study Group, a reactor is to be built for university use. The Federal Ministry of Education has ordered a TRIGA Mark II reactor from the General Dynamics Corporation, which will serve universities and technical schools.

● **Czechoslovakia** Improved reactor control has been claimed by the Reactor Laboratory Institute of the Czechoslovakia Academy of Sciences. The technique employs a single chamber device for recording the neutron intensity. This recording unit is movable and is directly linked to the control rods mechanism.

● **East Germany** Prof Manfred von Ardenne, a leading atomic physicist will be a member of Herr Grotewohl's party visiting Egypt, Iraq, India, Viet-nam and China.

● **West Germany** The AI research reactor at the University of Frankfurt was brought up to its full power of 50 kW.

● **Italy** 300 20% enriched U_3O_8 fuel plate assemblies for Agip-Nucleare's Argonaut type reactor have been ordered from the US Nuclear Materials and Equipment Corporation, who will recontract fabrication of the aluminium plates to M & C Nuclear Inc.

● **Italy** The Physical Institute of the University of Trieste has been awarded a £2500 contract by the IAEA. The project is to investigate and develop a new method of detecting fast neutrons such as in the space surrounding reactors.

● **Italy** The new premises of the Technical Institute of Electronics, Telecommunications and the Applications of Nuclear Energy, built by the province of Rome, have been opened by the Hon Aldo Moro, the Minister of Public Instruction. This Institute is now located in Via Trionfale, Rome.

● **Japan** As a result of clashes within the Government three cabinet ministers, including Mr Miki, director of economic planning and chairman of the Atomic Energy Commission, have resigned.

● **Pakistan** An institute for nuclear research and reactor technology is to be set up. Plans include a 1–5 MW reactor.

● **Thailand** The first reactor in Thailand of 1 MW is to be built at the Chulalongkorn University, Bangkok. The project under the director Dr S. Rudrakanchana will be implemented by the American Curtiss-Wright Corporation.

● **United Kingdom** 'The international trading situation is the least promising since the publication of the first GEC export guide in October 1956,' reports the January 1959 issue. 'The effects of the advent of the Common Market are evident and the immediate outlook for 1959 is gloomy. Trading opportunities since last October have become worse in eight countries—Australia, Denmark, Finland, Italy, Netherlands, Pakistan, Spain and Africa—and only in Ceylon are there signs of an improvement.

● **United Kingdom** A British manufacturer, Elliott-Automation Ltd has been successful in the American computer market, with orders for four of the new National-Elliott 802 computers incorporating special input and output devices.

● **United Kingdom** Mr William Strath has been appointed to succeed Sir Cyril Musgrave as permanent secretary of the Ministry of Supply. At present, Mr Strath is seconded from the Civil Service and is a full-time member of the board of the Atomic Energy Authority.

UNITED STATES Energy ranges of 10–1000 GeV have been explored by Professor Fretter and his assistant using a new technique on this cloud chamber at California University

● **USSR** An extensive collection of scientific periodical literature has been presented to the IAEA by the Academy of Sciences.

● **United States** Combustion Engineering has been chosen from 13 groups to operate the Argonne Low Power Reactor. Negotiations with the AEC are proceeding.

● **United States** Private industry is being approached by the AEC for undertaking, with Commission assistance, the design, construction and operation of a $M1·6 Gamma Process Development Irradiator for research and development on industrial applications of high-level radiation. An equivalent of 2 million curies of cobalt-60 is envisaged.

● **United States** Over 70% of the engineering and 10% of the manufacturing has been completed on the Westinghouse nuclear reactor plant, turbine generator, and electrical apparatus for the Yankee Atomic Electric Company's 134 MW pressurized water nuclear power station at Rowe, Massachusetts.

● **United States** Associates of the UK Integra, Leeds and Northrup, The Leeds and Northrup Co of Philadelphia, have received a contract valued at £225,000 from the Argonne National Laboratory for complete instrumentation and control systems for the Experimental Breeder Reactor No 2 (EBR-II), now under construction at the Atomic Energy Commission's National Reactor Testing Station.

● **United States** The AEC has proposed making available for public inspection correspondence with licensees relating to health and safety and compliance with regulations.

● **United States** A 4 lb battery for satellites which uses a polonium-210 source has been developed in four months by the Martin company of Baltimore and the Minnesota Mining and Manufacturing Co. Power is reported as 5 W and weight as 5 lb—against the 1450 lb of conventional batteries, which would give the same power over 276 days. Efficiency of thermal-electric conversion (see *Newsdesk* this month) is given at 10%.

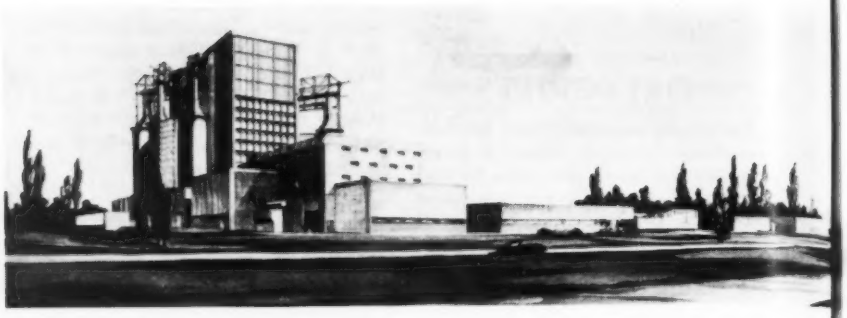
● **United States** Aerojet General announce plans to build a 10 MWt 3×10^{14} flux pool type loop test reactor at San Ramon by 1960.

● **International** Brazil, Pakistan and Thailand are to receive equipment and technical advice from the IAEA during 1959.

● **International** Two offers of calcined concentrate with U_3O_8 content have been made to the IAEA: the Atomic Energy Authority of South Africa quotes $21 a kg for 86%, the Belgian Société Générale des Minerais $18 a kg for 80%.

● **IAEA** An eight-member mission is visiting Burma, Thailand, Indonesia and Ceylon. This is the first of a series of preliminary assistance missions planned for 1959, to survey nuclear energy conditions and possibilities with the object of recommending the best means of aiding these countries.

● **IAEA** Dr Paul Ruegger, of Switzerland, a member of the Permanent Court of Arbitrations at the Hague, has been appointed chairman of the IAEA panel to consider atomic energy third-party liability problems.



Steps in designing a gas-cooled reactor

'How would you go about settling the main design features of a 150 MW station?'

There are as many answers to this question as there are designers: here is one of them, by Dr K. J. Wootton, Manager of The General Electric Company's Atomic Energy Division

ENQUIRY SPECIFICATIONS for nuclear power stations are frequently very detailed documents but to date it has been usual for much of this detail to refer to the conventional or near-conventional parts of the station such as the turboalternators and turbine hall, transformers and switchgear, administration buildings, site roads and so on. The reactor designer is usually free to develop the non-conventional parts of the plant his own way, subject only to the overriding necessity of persuading the client that he likes the design when it is completed. For this illustration it will be assumed that the reactor and associated plant has not been specified in detail by the company wishing to purchase the plant.

At the present time, for a station of 150 MWe we would put forward a layout based on a single CO_2-cooled reactor, natural metallic uranium-fuelled, graphite-moderated, as being the type on which design is most advanced. It should not be assumed that a British power reactor is *necessarily* of the gas-cooled, graphite-moderated type. None of the British consortia would wish to become so wedded to this type as to be thought incapable of designing and offering to construct reactors of another system. To date, however, we have found no reason to abandon gas cooling for the size of reactor under consideration here. On the contrary, our designs and very considerable research and development studies have shown this system to be still the most suitable for large base-load power stations.

What sort of element?

Having decided to offer one gas-cooled reactor as the heat source for the proposed station, the next step is to determine the type of fuel element to be used and its nominal maximum operating temperature, and to estimate its probable performance under a range of possible reactor conditions. Unless requested otherwise by the intending purchaser of the plant our fuel element would today be based on the use of natural metallic uranium and this will of necessity require the use of a canning material with a very low absorption cross-section to thermal neutrons. A magnesium alloy of the magnox type would probably be chosen. Beryllium has potential advantages but we feel that we have not yet built up sufficient experience in the use of beryllium to recommend it as a canning material for a commercial power station at the present time.

Now it must be a feature of the design that the temperature of every fuel element can shall be sufficiently below the melting point of the metal to permit safe operation even under fault conditions which result in temperature transients. The effect of fuel element temperature on possible fuel burnup must also be considered. Thus, if T_m is the melting point of the canning material, $\triangle T_1$ is the statistical variation which is to be applied to allow for variations in finning geometry and hence heat transfer performance, $\triangle T_2$ is the variation to be allowed due to inequalities of flow as between one channel and another (i.e. gagging inaccuracies), errors in temperature measurement during commissioning, position in the core and possible neutron flux distortions, and $\triangle T_3$ is the allowance for transient rise, then the maximum design temperature is

$$T_m - (\triangle T_1 + \triangle T_2 + \triangle T_3)$$

Obviously a design of fuel element in which $\triangle T_1$ is kept small is desirable.

How near the design limit derived as described above should be approached in practice is a matter for judgment by the designer. Possible considerations are:

1. can oxidization
2. distortion and eventual rupture of can due to swelling caused by en-

trained fission product gases, the effect of these gases increasing with burnup
3. anisotropic growth of uranium
4. operation of uranium too near the α-β phase change temperature, leading to excursions beyond this point during transients and undue stressing of the can as a result
5. temperature cycling
6. creep strength

Of these, the first has been shown to be negligible up to temperatures somewhat above 500°C in a CO_2 atmosphere for Magnox A12, and ignition does not occur before the melting point is reached. From the point of view of can melting, it is very doubtful if magnesium alloys can be used at temperatures above 500° C. Depending on the detailed design adopted, operating temperatures in current UK reactors range from the Calder figure of 408° C to 454° C.

How to support them

The method of fuel element support has an important bearing, not only on the design of the element itself and on the charging and discharging gear, but also on the maximum operating temperature selected by the designer. Basically there are two ways of supporting a column of fuel elements in a channel, which by this stage we will have decided shall be vertical:

a. simple stacking, the weight of each element and those above it being carried by the one below, the lowest element transmitting the weight of the whole column to the grid or other structure which is to carry the complete core
b. individually supporting each element, so that no uranium rod carries more than its own weight.

Method **a.** is obviously the simplest scheme, and is the one adopted in the Calder Hall and Chapelcross designs, but it will be seen that it relies on the creep strength of uranium. The use of **a.** will necessitate handling the fuel can itself during charging and discharging, with the resultant risk of damage to the can barrel or end fittings and to the rather fragile fins that are likely to be part of the outside of the fuel can. Scheme **b.** will permit the use of higher uranium temperatures and for longer periods as the creep strength of uranium metal will not now be a significant design limitation. The method of individual support can also be adopted to form a protection for the fuel element during charge and discharge, and greatly reduce the risk of jamming in the channel or damage to the element.

Individual support of each fuel element by means of graphite sleeves was selected for early Hunterston design studies some four years ago, and subsequent developments have confirmed the wisdom of that choice. For a new design such as we are now considering it is probable that the fuel element cartridge itself would show some differences from that shown on p 66 but the sleeve is likely to remain fundamentally unchanged. In addition to providing support for the fuel elements and facilitating handling, the graphite sleeves protect the main moderator blocks from the worst effects of any contamination or corrosion which may arise during the life of the plant. They also give a considerable degree of flexibility to fuel element detail design, and allow the bulk of the moderator to be operated over quite a wide range of temperatures in a way which is not possible with any other simple expedient. Graphite was originally selected as the sleeve material on the basis of its low neutron absorption cross-section and cost, together with its high compressive creep strength. No other material has yet been proposed to replace graphite in this application.

Choosing the parameters

Having decided on the fissionable and canning material and the maximum temperatures at which we wish them to operate, and having broadly selected a can design and method of fuel element support, we can now begin the rather complex business of optimizing the basic reactor parameters.

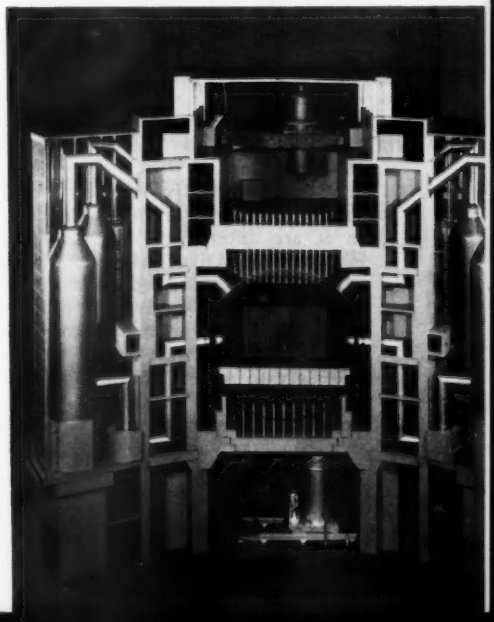
The centre fuel temperature and the can temperature are limiting features in the design of a nuclear power reactor. The heat flowing out of a unit length of fuel element will be proportional to its effective surface area per unit length and to the temperature gradient from centre to surface. It will be seen that, with a single solid cylindrical fuel rod, if these two limiting temperatures are fixed, the heat release per unit length of rod is virtually constant regardless of the rod diameter since the surface area is proportional to the radius of the rod and the centre-to-surface temperature gradient is inversely proportional to the radius.

Other things being equal, the heat output is therefore virtually independent of the rod diameter and the only variation is in the specific rating of the fuel, i.e. in megawatts per tonne of fissionable material. Of course variations in fin efficiency of the cans may make some difference to the effective surface area of the fuel as the rod diameter is changed, but this will not be an important effect for small changes in rod diameter such as would be considered with solid rods of natural metallic uranium.

If the rod diameter is reduced sufficiently it is possible to accommodate more than one rod in the cross-sectional area of a fuel channel and to increase the power rating per unit volume of the reactor as well as the specific fuel rating. For a single solid rod, however, a limit on the centre temperature means that the heat output per unit length can only be increased by reducing the surface temperature of the fuel element, which will be at the expense of lower coolant temperature, resulting in lower cycle efficiency, and there will clearly be an optimum combination of heat output and thermal efficiency which will give minimum costs.

The optimum combination

The assumptions made above that other things remain equal as the rod diameter is changed is, of course, incorrect. As the fuel rod diameter is varied the reactivity of the system, with the best combination of lattice pitch and channel diameter in each case, will vary widely, so that the possible total heat production will also vary. The result is that for a given centre fuel temperature there will be a combination of solid fuel rod diameter, channel diameter, lattice pitch, can temperature and coolant flow to give minimum generation costs possible with solid metallic uranium rods canned in whatever material is used. The economic optimum can temperature will be considerably below the centre fuel temperature, and whether this optimum is



While each 535 MWt Hunterston reactor has eight boilers (four are cut out in this model), four would probably now be sufficient for a 600 MWt station

within the limit set by the metallurgy of the canning material will depend on the material available. In this respect, metallic uranium and magnox are quite well-matched.

While for a single solid cylinder of fuel, fixing the centre fuel temperature and the can temperature fixes the heat rating per unit length, if other shapes of fuel element are considered the heat rating can be raised, since a change in the fuel element shape will enable the surface area to be increased without necessitating reduction of the temperature gradient from centre to surface. If this is done and the channel dimensions and the general type of can are not much altered, the blower power required to remove the greater amount of heat will, of course, be increased. It is therefore very important to distinguish between an increase in the specific fuel rating obtained at great expense in thermal efficiency by lower can and gas temperatures with a solid cylindrical fuel element, and an increase obtained with fuel surface temperatures and gas temperatures maintained at a high level by means of a change in the fuel element shape. Such a change can be of several kinds.

Blower power sets limit

The extent to which improvements in the heat rating per unit length of fuel element can be made by changes in shape will be limited by reactivity considerations and the degree of enrichment of fuel, if any, that is required. It will also be limited by the extent to which the blower power required to remove the additional heat increases. Generally speaking, if we are considering two fuel elements and cans of substantially similar type and operating at the same temperatures in channels of about the same dimensions, the ratio of blower powers will be approximately proportional to the cube of the ratio of heat ratings. The result is that, as the rating increases, the proportion of total power used by the blowers increases more quickly, so that the net electrical output increases at a slower rate than the fuel rating, and the net cycle efficiency is actually falling.

Since the capital costs per kilowatt of the reactor and of the fuel invested in it are affected by the net cycle efficiency as well as the specific heat rating, and the fuel replacement cost per kilowatt hour is inversely proportional to the net cycle efficiency, as the rating and the blower power necessary to remove the heat are increased, the total cost per kilowatt-hour has a minimum point at which the economic advantage of a further fall in the total capital costs per kilowatt due to higher rating is offset by the lower cycle efficiency.

Pressure vessel restrictions

At the same time as the fuel element designers and metallurgists are considering the specification of the fuel element, and the performance engineers are making preliminary optimization studies, the pressure vessel designers will be looking at various proposals for the vessel and its supporting structure. For a gas-cooled reactor of the type we are considering the pressure vessel may be in the region of 50 to 60 feet in diameter. This size of vessel cannot be transported to the power station site and consequently must be welded up in or adjacent to its final location. Now although vessels of up to 7 in. in thickness are commonly welded to Lloyd's class I standard in permanent workshops, it has not yet been considered feasible to go much above 4 in. plate thickness for site constructed vessels, largely because portable weld inspection apparatus of sufficient power is not available. The possibility of going above 4 in. plate depends on the development of suitable inspection gear and on the development of steels suitable for welding on site yet possessing adequate impact properties throughout the plate thickness for the whole working life of the plant.

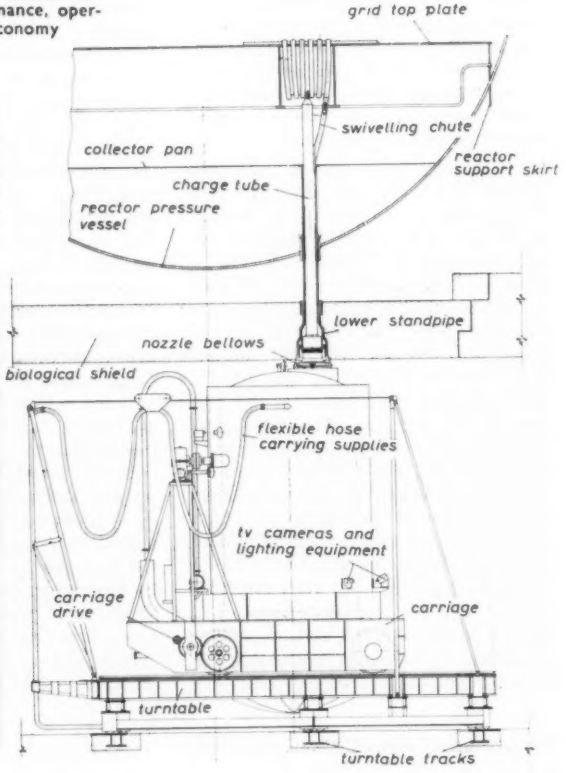
A final choice of reactor pressure vessel plate thickness cannot be made without careful consideration of the specification of the plate itself. Obvious desirable features are **a.** low brittle fracture transition temperature to minimize the possibility of cracks being propagated even when the reactor is shut down, **b.** adequate resistance to the harmful effects of irradiation during the design life of the reactor, **c.** good creep resisting properties, **d.** high ultimate tensile strength, **e.** good weldability, **f.** freedom from laminations.

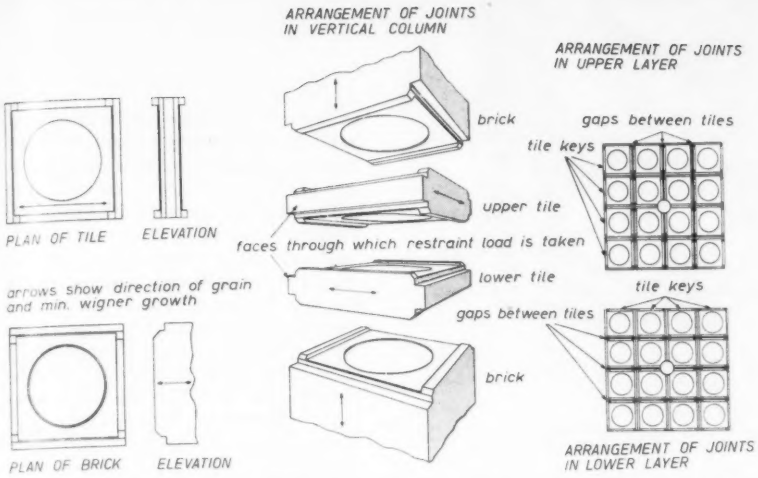
It may be desirable for reasons of cost, or on political grounds, to purchase as much as possible of the steel for the power plant in the country in which it is to be built. This fact may mean that some compromise will have to be made when selecting the pressure vessel plate. Thus a steel fully satisfying the above requirements may not be available in the required quantity or required thickness and with the high degree of uniformity of properties throughout the thickness which is so essential. For Hunterston an aluminium killed steel produced by Colvilles, Coltuf 28, is being used, and until considerably more experience on the effects of irradiation on other steels is built up this choice would seem still to be a reasonable one.

FUEL AND FUELLING

Bottom charging was chosen for Hunterston and would again be a feaure of the new station on grounds of easy maintenance, operational safety and economy

The graphite sleeve of the Hunterston fuel element is likely to remain in the 150 MW design, although the can—now longitudinal finned with spiral splitters—would probably change





By running the reactor at higher temperatures, Wigner growth will be virtually eliminated and the graphite core structure will probably be simpler than the Hunterston one shown here

Protecting the vessel

It is not to be expected that any steel will fill the requirements which have been listed as adequately as could be wished and it will therefore be necessary for the pressure vessel engineers to design around the shortcomings of their material. Thus Coltuf 28 has not as good creep resistant properties at elevated temperatures as we would wish and consequently if we are not to be forced to restrict our gas outlet temperature, some way must be found of preventing the top of the vessel from becoming too hot. Insulating materials in the form of thin stainless steel sheet are now commercially available which can safely be used to line the inside of the upper part of the reactor sphere. By this means, and by keeping the external lagging on the pressure vessel relatively thin, the temperature of the sphere can be designed to be nearly uniform and safely below the temperature at which significant creep begins to occur.

An alternative to interior insulation attached to the pressure vessel is to use an inner shell to contain the hot gas, such a shell being designed to withstand only the pressure drop across the reactor core and not the full absolute pressure of the gas in the system. This arrangement of a 'top hat' liner within the pressure vessel is being used at Hunterston and is very satisfactory for its purpose. In fact the use of an inner shell would probably permit the employment of higher gas temperatures with the same pressure vessel steel and thickness than would be economically feasible with interior lagging. If we are using metallic uranium fuel canned in magnox, however, it is unlikely that we will be able to take full advantage of this feature and the need to pack the largest possible core in a given size of pressure vessel will assume overriding importance. To achieve this high utilization of pressure vessel volume it is probable that the internal lagging now available will be decided upon.

The choice of pressure vessel steel and plate thickness means that a unique relation is now available between sphere diameter and carbon dioxide working pressure. From the heat transfer and fluid flow point of view the higher the gas pressure the better, but the allowable diameter of the vessel will fall as the gas pressure rises, the two being in inverse proportion. The optimization studies will by this time have indicated the required core sizes to meet the specified power output for a variety of coolant gas pressures, but before the pressure vessel diameter can be provisionally decided on it will be necessary to determine the basic fuel element charge and discharge arrangement.

On-load fuelling

In the United Kingdom we have always considered that a reactor of a nuclear power station must be capable of having fuel elements inserted and removed with the plant on full load. It is, of course, quite possible to design fuel elements capable of long burnup and arrange for the plant to be shut down for major fuel changes. But any such batch handling procedure makes no provision for dealing with random fuel element failures which, statistically, are bound to occur and can only lead to unscheduled plant shut downs. The absence of on-load charge/discharge facilities also makes it impossible to consider any form of fuel shuffling from regions of high flux in the core to regions of lower flux and vice versa, and thus we lose a valuable means of fuel economy. It is probable, therefore, that the 150 MW station under consideration will include on-load fuel handling.

There are two alternative approaches to the problem of charge/discharge of a reactor with vertical channels: the fuel elements may be fed in and removed from either above or below the core. These alternatives are usually referred to as top or bottom charge. Discussion of the relative merits of these arrangements tends to be clouded by precedents. The design team engaged on Hunterston, for example, would be expected to favour bottom charge, whilst designers of the other groups might be expected to prefer the alternative. For a new design, however, it is most important that the pros and cons should be considered afresh and an attempt made to reach the best engineering solution without preconceptions.

From top or bottom ?

It must be said at the outset that top charging is likely to be cheaper in first cost than a bottom charging scheme. This difference in cost arises from two main facts :

a. it is possible to get a slightly larger core in a sphere of given diameter if top charging is adopted

b. a reactor with bottom charging will probably be higher overall than one with top charging, and the method of support of the pressure vessel may be made somewhat more expensive by the need for allowing the charge machine to gain access through the bottom dome.

These extra costs, however, are not a large percentage of the capital cost of the reactor and it is felt that they are much more than offset by the advantages of the bottom charging scheme. Even a small increase in attainable plant load factor, or increase in mean fuel element burnup through shuffling, will bring significant financial advantages.

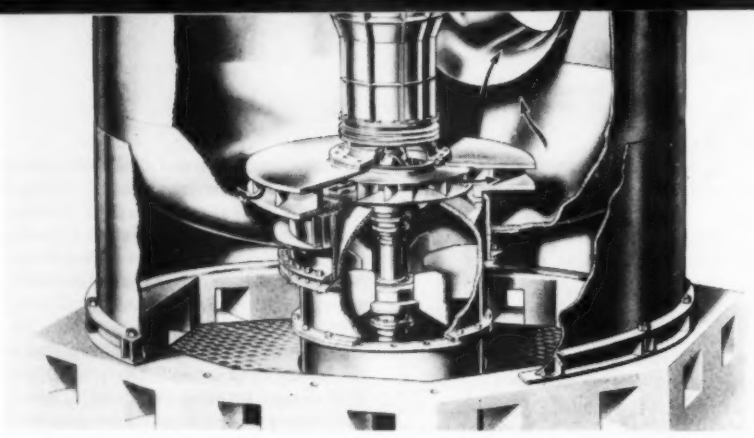
The considerations of ease of maintenance and operational safety and economy were among the factors which decided us to design Hunterston with fuel charging from underneath the core. Other factors which led us to favour bottom charging are:

a. charge and discharge operations are not conducted in an area where control operations also take place

b. access to the fuel is possible from both ends of the channels

c. the entire stack of fuel elements in one channel is handled in one operation, thereby increasing the speed of the operation and reducing the risk of damage to the fuel elements by grabs or other devices which for top charging would have to engage with each individual fuel element

d. operations take place at the cool



Proven reliability, flexibility and ease of incorporation in the circuit were the grounds for GEC's choice of centrifugal blowers. The single-stage impeller is mounted in the base of the boiler pressure shell

gas inlet end of the reactor ; under these conditions neither the fuel elements nor the charging equipment are subjected to violent thermal shock

e. since no components other than fuel elements enter the core, the amount of induced activity in the charge machine will be greatly reduced

f. the charge machine, being at ground level, is easily accessible for routine maintenance.

How many control rods ?

An aspect of the charge/discharge problem which has become important since the first round of nuclear power stations were designed in the UK is the requirement for an increasing number of control rods as the rating of reactors increases. Thus at Hunterston provision is made for one control rod to every 16 channels, and for reactors of higher specific power a greater rod density will be necessary. With a top charging scheme it is difficult to accommodate one rod to 16 channels and an increase in this ratio borders on the impossible.

It should be mentioned that the increased height of the reactor building resulting from the use of bottom charging may in certain circumstances have technical as well as financial disadvantages. Thus if the proposed site of the nuclear power station is subject to earthquakes the importance of keeping the centres of gravity of all plant items as low as possible, to reduce the risk of overturning, may override all other considerations. Such circumstances, however, are rare and do not hold anywhere in Europe.

Having decided on the method of charging it is now possible to go back and fix tentatively the main vessel diameter and CO_2 gas pressure. An important consideration remaining, however, is the design of pressure vessel support which is to be adopted. As with charge/discharge schemes, there are basically two alternative arrangements in use today : firstly, a continuous skirt support which may be cylindrical or conical in form, or secondly, a series of discontinuous supports which may be many or few in number and which may assume a wide variety of forms.

Skirt design a compromise

The skirt support may be welded to the pressure vessel or the junction between skirt and pressure vessel may be effected through a series of forgings of cruciform section incorporated as a ring in the lower part of the vessel itself. If a skirt support is adopted a compromise has to be made between the conflicting requirements that the induced stresses in the pressure vessel due to the support must be kept down, but at the same time the design must be practical and satisfactory fabrication must be possible even under somewhat difficult conditions which may prevail on site. Thus, from considerations of stress, the diameter of the skirt support in plan should be equal to the maximum diameter of the pressure vessel. To support a sphere and contents, weighing perhaps 6000 tons, on its equator is, however, somewhat impracticable, and the need for large gas inlet and outlet ports makes such an arrangement quite out of the question. A compromise has therefore to be made. It may be said that, in general, the smaller the diameter of the skirt relative to the diameter of the pressure vessel the easier the fabrication problems become. Conversely, with reduction in skirt diameter the risk of distortion of the bottom dome of the pressure vessel increases. For a given diameter of skirt supporting a pressure vessel of known dimensions, a skirt plate thickness can be calculated which will result in minimum induced stresses in the pressure vessel.

With the adoption of a discontinuous support of the pressure vessel, relative ease of fabrication may be obtained at the price of greater uncertainty in the stress distributions in both pressure vessel and supports. The final stages of assembly of the vessel on its supports may involve extensive levelling operations which can be more complicated than in the case of the skirt support.

The core of a gas-cooled, graphite-moderated reactor is conventionally built up of a stack of bricks of graphite interspersed with smaller graphite blocks known as tiles. This particular arrangement has been adopted in the past, first in order to simplify graphite machining problems and to avoid the build up of unacceptable machining tolerances, and secondly so as to permit Wigner growth and at the same time maintain a rigid stable graphite structure. Experience over recent years, however, has shown that it is desirable to run the moderator at a rather higher temperature than formerly so that Wigner growth is negligible over the foreseeable life of the reactor. The virtual elimination of Wigner growth should result in a simplification of graphite core design. The stabilizing structure around the outside of the core will no doubt remain.

Work on the heat exchangers, steam raising units (SRU's) or boilers, as they are variously called, will be going ahead as the reactor design begins to take shape. For a reactor with heat output of around 600 MW it is probable that four SRU's will now be sufficient. Experimental studies on extended surface boiler tubing together with design techniques to enable the greatest area of such tubing to be incorporated in a given volume of SRU shell permit of considerably higher steaming capacities than was previously thought possible.

Blower speed control

The remaining major components of the primary coolant circuit are the gas ducts, valves, expansion bellows, and, most important, CO_2 circulators (or blowers) and their associated drives. The reliability and efficiency of the coolant gas circulators and their drives are obviously of extreme importance for the safety of the station and its economical operation at high load factor. Either an axial or centrifugal type blower may be chosen. The circulators are required to handle large mass flows with low pressure ratio, and in these particular circumstances an axial flow machine is likely to show very little improvement in efficiency over a centrifugal blower. The choice is likely to rest mainly on considerations of proven reliability and flexibility of performance under varying conditions and ease of incorporation in the gas circuit. For Hunterston, the GEC's centrifugal machine was chosen, with

the single stage impeller mounted in the lower end of each heat exchanger shell. They are arranged vertically with impellers and diffusers inside the shell and the drives outside. This arrangement simplifies and cheapens the gas circuit, avoids the necessity for the use of more than one seal on the impeller shaft, and obviates the need for a separate pressure casing for the gas circulator.

Since the mass flow through each circulator is required to vary over a wide range, some form of blower speed control, throttling or by-passing is essential. Throttling or by-passing may be dismissed immediately on grounds of efficiency and complexity. A suitable system of variable speed drive has therefore to be selected. Among the possibilities are turbo-electric, Ward Leonard and fluid drives, but after careful consideration these were discarded for Hunterston in favour of a grid-controlled, mercury-arc rectifier, d.c. system. This latter system has the advantage of low initial cost and wide speed range, and also the main blower motors may be coupled direct to a battery supply in the event of a complete power failure in the system. This d.c. drive arrangement, however, is not suitable for unit blower powers much in excess of those employed at Hunterston, and the new 150 MW design would probably incorporate one of the alternative drive systems.

Flexibility built in

No mention has yet been made of the civil engineering works which form an integral part of a nuclear power station. In planning the layout of the reactor and its coolant circuits and the arrangement of the station as a whole, the civil designers work closely with the mechanical engineers. Experience has indicated that the liaison must be on a day-to-day, almost hour-to-hour basis in the early stages of the design if a safe and economic plant is to result. Proposed erection procedures will be considered during these early days, as the method finally adopted will have important effects on the design and layout of the station.

The science and art of nuclear reactors are developing rapidly and for a design to be successful it is necessary that it should have built into it a measure of flexibility which will allow modifications to be incorporated up to a late stage of construction. In this way advantage can be taken of the progress which will occur during the four to five years which will elapse from the inception of the design to full load running.

Full understanding of boiling effects is important for both BWRs and non-boiling, liquid-cooled reactors. Last month Roberts and Bowring defined the language of the subject. Here they begin a two-part article reviewing the present position of boiling theory, particularly where it touches on the related fields of heat transfer and burnout

Boiling effects in liquid-cooled reactors

by H. A. ROBERTS, B.Sc., A.K.C., A.M.I.Mech.E.
and R. W. BOWRING, M.A.(Oxon)
Reactor Division, A.E.R.E., Harwell

REACTOR SYSTEMS with liquid coolant may be divided into two broad operational classes—boiling and non-boiling. In boiling reactors, only water (heavy or light) has been regarded as a practical proposition as a boiling coolant e.g. EBWR and Halden. In non-boiling reactors, at present boiling of any kind is suppressed in normal operation, although it may be permitted under transient or emergency conditions as long as there is no danger of burning out the fuel elements, and it is in this respect that knowledge of boiling effects is important for non-boiling reactors. A variety of liquids may be considered as non-boiling coolants in reactors but in this paper we shall deal, in the main, with water because of the more advanced state of knowledge and the wider, more immediate application.

BUBBLE DYNAMICS

Without considering relevant aspects of bubble formation, full understanding of boiling is impossible. Bubbles, by the turbulence which they promote within the boundary layer during their growth, and by their stirring action as they rise in the liquid, are the principal factors in increasing heat transfer and pressure drop. In the following paragraphs a brief account of bubble

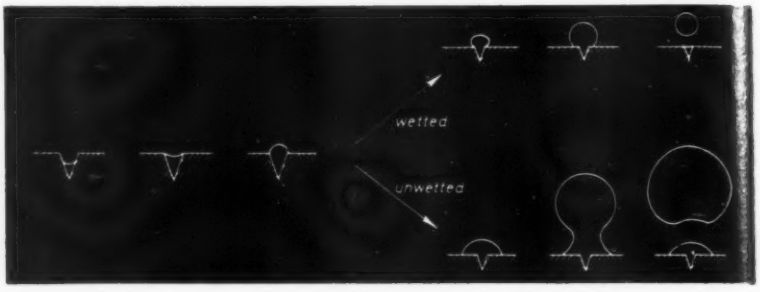
nucleation, bubble growth and bubble departure or collapse is presented. These are important where they affect the correlations discussed in subsequent sections.

Nucleation centres

A bubble, in forming, needs energy to convert the liquid to vapour and to generate a surface (surface energy), and these energies may be derived from the liquid if it is superheated. The degree of superheat necessary to initiate a bubble is controlled by the surface tension forces and, in the absence of nucleation aids—such as using deaerated water and scrupulously clean, unscratched glass—very high degrees of superheat may be attained in reasonable agreement with values expected from the Van der Waal equation. Normally these maximum values are not even approached in boiling systems and consequently boiling depends on nucleation aids which effectively enable the bubbles to start from a small but finite radius. Dissolved gas coming out of solution acts as a very effective nucleus, but since it is largely carried away when the bubble detaches, other nuclei are necessary if boiling is to continue. The energy barrier which must be overcome before a bubble can undergo dynamic growth depends strongly upon the contact angle and is a maximum for a perfectly wetted surface and zero for a completely non-wetted surface. However, a surface which is poorly wetted over its entire area is most unsuitable for boiling, because although bubbles readily form at low superheat they do not detach so easily but coalesce to promote film boiling with the risk of burnout.

The ideal boiling surface would appear to be one which is wetted (i.e. the contact angle less than 90°) over most of its area but with microscopic, unwetted nucleation centres. Perhaps one of the best nucleation centres would be an unwetted (contact angle greater than 90°) tapering crevice. Surface tension would prevent the crevice from ever being completely filled with water, thus providing a permanent region of vapour for bubble initiation. Unwetted patches on the flat surface may also act as nucleation centres. Such unwetted patches might be caused by impurities or by gas adsorbed at a fault in the crystal lattice (*1*). Once the bubble had started to grow, its base would expand outwards into a wetted portion of the heated surface where it could more readily detach (figure 1).

The physical conditions of the nucleation centre determine the degree of superheat necessary to allow a bubble to grow and this explains why, at low heat fluxes, columns arise from only a few nucleation centres, but, as the heat flux is raised, the number of nucleation centres increases much more rapidly than the rate of bubble production. With increasing heat flux the temperature of the superheated layer in contact with the heated surface increases, enabling the less favourable unwetted patches to act as nucleation centres. Jakob (*2*) found an almost linear increase of nucleation centres with heat flux, each corresponding to an increase of about 700 Btu/ft²h.



A vapour bubble may nucleate in a microscopic, unwetted pit in a heated surface. Its size on detachment depends on whether the surface is macroscopically wetted or unwetted (Fig 1)

In a reactor, two other nucleation aids would tend to promote boiling: the effect of ionizing radiation and the presence of the oxygen and hydrogen from the radiolysis of the water. In the former, the potential energy barrier which must be surmounted before a bubble nucleus can form would be reduced by the mutually repulsive effect of neighbouring charged molecules. For the latter, apart from their effect on nucleation, the presence of bubbles of free oxygen and hydrogen might also increase the heat transfer in the forced convection non-boiling region. This may be the explanation for the greatly enhanced heat transfer coefficient reported for SUPO (*3*).

Bubble growth

Study of the bubble growth problem has received close attention in recent years. In the experimental field, photographic studies of surface boiling in stagnant, subcooled water at atmospheric pressure have shown that bubbles may grow and collapse again without detachment in rapid succession. The life of a bubble under the conditions of an experiment (*4*) was ½–1 millisecond, depending largely upon the heat flux, and the maximum radius attained was about 0·020 in., depending upon the thickness of the superheated layer and thus upon the degree of subcooling. A bubble initiated in the superheated layer received sufficient impetus through the relaxation of the surface tension forces as it grew in size to penetrate into the subcooled region above. Here its rate of growth was checked and, having overshot, it began to collapse again. As it collapsed, cold water was dragged down from above driving it to complete collapse. At lower degrees of subcooling, the bubble grew large enough to detach and rise into the cooler water above before collapsing. Experiments under conditions of forced convection gave similar results but the bubble travelled along the heater element surface during its growth and collapse cycle (*5*).

Experiments on growth

The mathematical treatment of the bubble growth problem is difficult and the only case which has been considered in detail is that of 'volume' boiling. Although this case is rarely met with in practice, some of the results may be applied, with certain reservations, to the more practical case of nucleate surface boiling. Once a bubble, initiated in a superheated liquid and remote from any solid surface, has started to grow, surface tension forces rapidly become negligible. The bubble radius does not increase as rapidly as might perhaps be expected because the evaporation of liquid into the bubble reduces the temperature in its immediate vicinity and thus the driving force making the bubble grow. From theoretical studies of a bubble growing under these conditions (*6, 7*) the conclusion has been reached that, to a good approximation, the bubble radius increases as the square root of time. This conclusion is also valid for an undisturbed bubble growing on a heated surface, provided certain simplifying assumptions are made (*8*). In both cases, experimental evidence is confirmatory (*9, 10*). In the heat transfer section it will be seen how Forster and Zuber (*11*) used the

relation $R \propto t^{\frac{1}{2}}$, i.e. $R.dR/dt$ = constant, as the basis of a correlation for boiling heat transfer.

Bubble departure

With the bulk liquid at or near saturation temperature, a bubble may grow large enough for its buoyancy to overcome the capillary force holding it to the heated surface so that it can detach and rise through the liquid. The force holding a bubble to the surface depends upon the contact angle. For a well wetted surface, the volume of a bubble for a given circle of contact is comparatively large and quite small bubbles may leave the surface. On the other hand, for a poorly wetted surface, e.g. water on an oil film or mercury on stainless steel, the volume for the same circle of contact is small and a bubble must develop a waist before leaving. Under these conditions, bubbles leaving the surface are large (figure 1).

A simple empirical equation (*12*) relates the volume of the bubble at breakaway V_b to the contact angle β and the Laplace constant a.
Thus

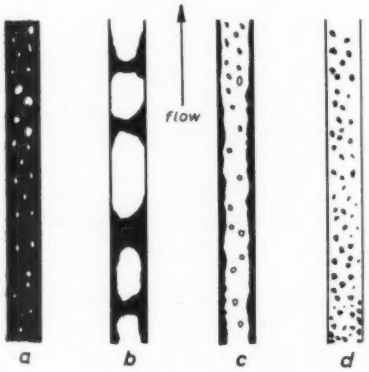
$$(V_b)^{\frac{1}{3}}/a = 0{\cdot}0119\,\beta \qquad (1)$$
$$\text{for } 0 \lesssim \beta \lesssim 140^\circ$$

The Laplace constant, which often appears in surface tension calculations, is defined thus

$$a = \sqrt{2\sigma/g(\rho_l - \rho_v)} \qquad (2)$$

where, in consistent units,

σ = surface tension
g = acceleration due to gravity
ρ_l, ρ_v = densities of liquid and vapour



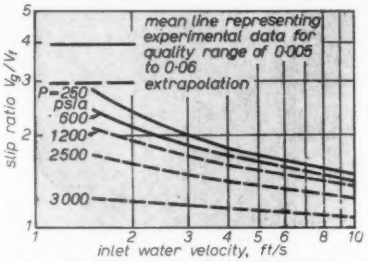
Various forms of two-phase flow are possible in a vertical tube including: a. bubble flow, b. plug flow, c. annular flow, d. dispersed or fog flow (Fig 2)

At comparatively low heat fluxes in boiling heat transfer, the bubbles breaking away from the heated surface remain separate. As the heat flux is increased, the rate of bubble production from each nucleation centre also slowly increases until the bubbles follow each other so closely that they interfere with one another to form continuous oscillating vapour columns (*13*). These modes of bubble release have a considerable effect upon boiling heat transfer coefficients and pressure drop.

TWO PHASE FLOW

As well as its effect upon heat transfer, vapour production at the heated surface and the forms of flow which the combination of vapour and liquid assume when they flow together in a channel have gross effects on the pressure drop and on the mean density to be taken when estimating the neutron moderating properties of a two-phase coolant.

Essentially, the forms which flow may assume in a vertical channel



Estimated variation with velocity and pressure of slip ratios i.e. the ratio of steam and water phase velocities (Fig 3)

(figure 2) are: a. bubble flow, in which dispersed vapour bubbles move in individual paths in the liquid; b. three successive unstable patterns which are called, respectively, plug flow, dispersed plug flow, and froth flow, and which are transitional patterns between bubble and annular flow; c. annular or climbing film flow, in which the liquid travels up the tube as an annulus in contact with the tube walls while the vapour, together with a small quantity of liquid in drop form, occupies the centre portion of the tube; d. fully dispersed homogeneous or fog flow, in which all the liquid is entrained as droplets in the vapour. In general the flow pattern may be determined by the volumetric vapour fraction and the Froude number (*14*), but as yet no reliable data have appeared for steam and water at high pressures. All these forms of flow are conceivable as normal operating conditions in the boiling type reactor and are possible, under emergency conditions, in boiling and non-boiling reactors. Little is known of the effects of flow pattern on burnout heat flux and pressure drop in steam-water system.

In two-phase design calculations it is customary to adopt a simplified, if not strictly correct, flow model in which all the steam has one velocity and all the water another, and because the steam moves more quickly than the water, there is said to be a 'slip-velocity' between the two phases. Alternatively, 'slip-ratio,' the ratio of the steam and water velocities, may sometimes be a more useful parameter. Slip data may be used to determine the voidage in a liquid moderator, as well as being necessary for two phase flow calculations (figure 3) (*15*).

PRESSURE DROP

The action of viscosity in turbulent single-phase fluids is confined to a narrow region at the boundaries of the containing flow passage. In this region large changes in fluid velocity can occur, giving rise to the viscous forces associated with frictional pressure drop. The importance of this laminar boundary layer cannot be too highly stressed. Experiments have shown that microscopic roughnesses can exert a considerable influence on the frictional pressure drop in a channel in which the fluid is flowing turbulently, and the degree of disturbance caused by these minute roughnesses may exercise an over-riding influence on pressure drop (*16*).

Subcooled boiling pressure drop

In subcooled nucleate boiling in a flowing system, surface bubbles may be observed growing to sizes considerably greater than boundary layer thicknesses. The pressure drop, at the same time, depending on the conditions, may show a significant increase over the non-boiling value. Existing correlations for subcooled nucleate boiling pressure drop are at present few, limited in scope, and should be used with caution.

Rohde (*17*), using Buchberg's data, obtained the equation

$$\left(\frac{dP}{dL}\right)_B \Big/ \left(\frac{dP}{dL}\right)_{NB} = \exp 384\left(\frac{q''_B}{q''_{NB}} - 1\right) \Big/ P$$

where P is the system pressure in psia, $\frac{(dP)}{(dL)_B}$, $\frac{(dP)}{(dL)_{NB}}$ the pressure gradients for liquid flow with and without boiling respectively, and q''_B, q''_{NB}, the boiling and maximum non-boiling heat flux under the same conditions, respectively.

Buchberg's experiments, from which this correlation was developed, were made with the following variables:

pressure: 100–2000 psia
velocity: 10–30 ft/s
heat flux up to 2×10^6 Btu/ft²h
diameter of tube: 0·226 in.
length of tube: 24·6 in.

Bulk boiling pressure drop

Nucleate boiling with net steam generation is accompanied by expan-

sion of the fluid along the tube, since bubbles progressively leave the tube wall and flow with the water. The fluid is continuously reduced in density and accelerated and thus the overall pressure drop is modified. The overall pressure drop $\triangle P$ may be equated with the separate pressure drop factors as follows:

$$-\triangle P = -\triangle P_z - \triangle P_a - \triangle P_f$$

where the terms of the equation are defined below.

The hydrostatic pressure drop $\triangle P_z$ is the product of the vertical height and mean fluid density in the channel length under consideration.

The acceleration pressure drop $\triangle Pa$ is given rigorously by the equation

$$-\triangle Pa = \frac{G^2}{g}\left(\frac{1}{\rho_2} - \frac{1}{\rho_1}\right)$$

where G is the mass flow rate per unit, a (mass velocity) and ρ_1, ρ_2 the mean fluid densities at the upstream and downstream stations respectively.

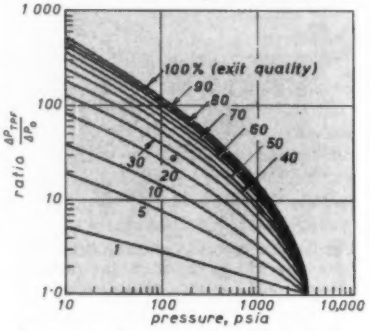
The uncertainties in the values of the mean fluid density, introduced by steam slip, do not allow accurate prediction of the hydrostatic and acceleration pressure drop losses in the region of pressure 0–1500 psi, although approximate values may be calculated from the slip data quoted earlier, or by using the empirical Martinelli-Nelson correlation, which will be discussed later.

The frictional pressure drop $\triangle P_f$ in steam generating systems is difficult to correlate comprehensively because of the different regimes of flow and boiling which may be involved and which can affect wall conditions. There are also other important unknown factors which make prediction of two phase frictional pressure drop difficult. These include a. the degree of liquid superheat prevailing under given conditions, b. the effect of wall roughness, c. the distribution and relative velocities of steam and water in a flowing system, d. the effects of channel dimensions, e. the effect of heat flux, and f. the sonic velocity, which may be very low for a homogeneous mixture of water and steam (*18, 19*).

Homogeneous theory

Historically, the first approach to the problem of pressure drop in two phase flow was on the assumption that the steam-water mixture could be treated as a homogeneous fluid, i.e. that the two phases were in thermodynamic equilibrium and there was no slip. The results predicted from this theory, as applied to the Fanning friction equation and using suitably modified physical properties, are found to be in error at the lower pressures below, say, 1500 psi. In this range the influence of steam slip and superheat are significant; hence the most valuable experimental results are those where density and temperature traverses in the flow passage have been made. Conclusions which may be drawn from existing experimental data in this pressure region are that both increasing velocity and increasing heat flux in the nucleate boiling regime have the effect of tending to decrease the discrepancies between homogeneous theory predictions and experimental measurements.

At higher pressures, and particularly near the critical pressure 3206 psia, the behaviour of the steam-water mixture would be expected to approximate more closely to that of a single phase homogeneous fluid. This has been confirmed by experiment; the divergence between values of pressure drop calculated from the homogeneous theory and those found experimentally was



Ratio of $\triangle_{TPF}$ to $\triangle_O$ as a function of exit steam quality and absolute pressure. $\triangle P_{TPF}$ is the two-phase frictional pressure drop and $\triangle P_O$ the pressure drop if all the fluid were flowing as water at saturation temperature (Fig 4)

found to be small above about 1500 psi for the following conditions: a. low heat fluxes in the bubble flow regime, b. well established turbulent flow in smooth or slightly rough tubes, c. velocities in the region 4–8 ft/s, and d. tube diameters of the order of 1 to 3 inches (*20, 21*).

Martinelli-Nelson correlation

In the Martinelli-Nelson (*22*) method an attempt is made to correlate two-phase pressure drop data for steam-water mixtures on the basis of the following assumptions:

a. the pressure gradient is the same in the liquid as in the vapour phase
b. the volume of the channel is equal to the volume of vapour plus the volume of liquid
c. vapour and liquid in the channel are both in turbulent flow
d. a linear relationship exists between vapour quality and tube length.

This correlation was developed from an earlier one of Lockhart and Martinelli (*23*) for the frictional pressure drop for air-liquid combinations flowing in horizontal tubes. It was adapted for steam-water pressure drop and adjusted to suit the experimental data of Woods, and of Davidson *et al.*

The frictional pressure drop was non-dimensionally presented as

$$\frac{(\triangle P/\triangle L)_{TPF}}{(\triangle P/\triangle L)_g} = \Phi^2{}_g$$

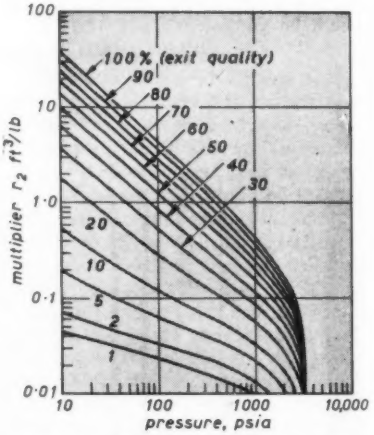
where $(\triangle P/\triangle L)_{TPF}$ is the two phase flow pressure gradient, $(\triangle P/\triangle L)_g$, the pressure gradient that would be obtained if the vapour alone was flowing and occupying the whole tube, and Φ_g, a correlating factor. Φ_g was found from the experimental data to be an empirical function of a dimensionless variable χ^2 which was correlated in terms of steam quality, the density and viscosity ratios of vapour to liquid, and the pipe diameter. Figure 4 represents the curves derived for frictional pressure drop on the basis of the Martinelli-Nelson correlation for steam and water.

The acceleration pressure drop was correlated by Martinelli and Nelson as

$$\triangle P_\alpha = r_2 \frac{G^2}{g_c}$$

The expression for r_2, the correlating factor, was

$$r_2 = \left\{\frac{(1-x)^2 v_l}{R_l} + \frac{x^2 v_g}{R_g} - V_l\right\}$$



Variation of circulation factor, r_2, for two-phase acceleration pressure drop with absolute pressure for various exit steam qualities. Pressure drop due to acceleration of the fluid during evaporation equals r_2G^2/g_c (Fig 5)

where x is the steam quality, R_l, R_g area fractions of the tube filled with liquid and vapour respectively, v_l and v_g the specific volumes of liquid and vapour respectively (figure 5).

No correlation was presented for hydrostatic pressure drop since the analysis was based on horizontal tube experiments. However, this method is at present widely used for calculating vertical channel evaporation over vir-

tually the whole pressure range although no experiement has yet confirmed a high order of accuracy. One may rule out as inadmissible in this context experimental work with horizontal channels and at atmospheric pressure; in the former case, horizontal tube two-phase flow patterns are different from vertical tube patterns because of gravitational effects, and in the latter the effects of superheat lead to large discrepancies at low pressures. In addition, at low pressures considerable errors are introduced by the relatively large change in saturation temperature along the tube with change in pressure.

Experimental evidence indicates that at pressures up to 1400 psi for small diameters and narrow channels, and heating rates up to 342,000 Btu/ft²h, discrepancies may be of the order of ±50% (*24*). At pressures of 1100 and 2000 psi, for vertical rectangular channels 1·0 in. by 0·097 in. by 27 in. long and for mass velocities 2–4 × 10^6 lb/ft²h the pressure drop calculated from the Martinelli equation was consistently higher than that found in practice. The discrepancy was greatest at low steam qualities (*25*).

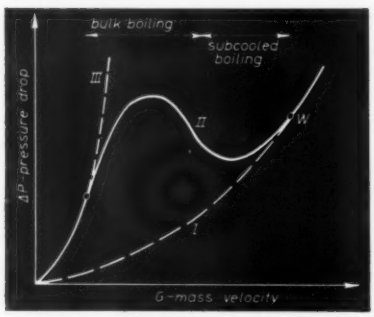
Instability of flow

It has already been noted that unstable patterns of flow can occur in the transition from bubble to annular flow and these may give rise to fluctuating pressure drop in the two-phase region. Since the amount of net flow rate variation depends upon the change of the overall flow resistance of the whole circuit, the flow oscillations arising from this cause would not be serious as long as the resistance of the single phase portion was relatively high.

However, flow instabilities are also possible in systems where heat supply and pumping energy are independent, as in a nuclear reactor or a boiler system. In the former, flow instability may lead to embarrassing power fluctuations and possibly even burnout.

In order to explain how this form of flow instability may occur, let us take the simple example of a bundle of tubes in parallel through which subcooled water is being pumped. With constant heat flux but no boiling, flow through each tube may be assumed roughly equal and the pressure drop, including entry and exit losses, follows a well established curve (figure 6, curve I).

With the possibility of boiling, the precise value of the flow rate through each of the tubes becomes more critical. In any one tube, should it fall below a value denoted on the graph by *W*, first subcooled boiling and then bulk boiling may occur, giving a pressure drop characteristic similar to that of curve II in figure 6. For a constant header-to-header pressure drop, determined by the single-phase flow through the unaffected tubes, two or even three values of flow are possible. Fluctuations in local pressure drop, if they are large enough to cause boiling, may result in instability and the flow would oscillate continuously between the normal and a lower flow rate for as long



Relation between fluid mass velocity and pressure drop across a heated channel I. for single-phase liquid, II. with boiling, III. for single-phase steam (Fig 6)

as the original conditions prevailed.

Factors influencing this type of instability are the system pressure, frictional properties of the channel, inlet and outlet resistance and the subcooling at inlet. A criterion for stability based on the homogeneous theory illustrates this a follows (*26*):

$$\frac{\frac{fS}{A} + K_i + K_e}{\frac{1}{2}\left(\frac{\rho_l}{\rho_v} - 1\right)(2 + K_e)\left(\frac{C_p \triangle T}{\lambda}\right)} \geqslant 1$$

where, in consistent units, f = single phase friction factor, S = channel surface area, A = flow area, K_i, K_e = inlet and exit loss coefficients respectively, ρ_l, ρ_v = liquid and vapour densities respectively, C_p = liquid specific heat, $\triangle T$ = subcooling at entry, and λ = latent heat of vaporization.

The assumptions are:

1. The water at outlet is at saturation temperature
2. The frictional pressure drop change resulting from steam generation in the exit portion of the tube is small compared with acceleration and exit effects
3. the increase in pressure drop due to subcooled nucleate boiling, which is shown to be a stabilizing factor, may be neglected
4. flow is assumed homogeneous and pressure drops are estimated on the homogeneous theory.

It may be noted that the stability can be increased by any of the following methods:

a. increasing the value of fS/A
b. increasing the inlet resistance
c. increasing the pressure
d. decreasing the degree of subcooling at inlet for the same fluid conditions at outlet.

Oscillations of water

In a boiling water nuclear reactor, other forms of instability are possible giving rise to periodic variations in power output i.e. 'chugging.' These are connected with oscillations of the water in the core vessel and the complete hydraulic loop (*27*). The former may be associated with 'sloshing,' the side-to-side motion of the water, initiated perhaps, by steam formation in the core. The latter may be similar to that obtaining in a conventional natural circulation boiler system where the water in the evaporator tube may oscillate about a mean level. If the liquid should be driven below its equilibrium level, heat stored in the exposed portion of the pipe would cause the returning liquid to be driven back again with almost explosive violence. The oscillations would be maintained and the period determined by the mechanical inertia of the system. In a reactor, the effect would be aggravated by the change in reactivity with steam voidage.

The fundamental basis of flow instability analysis is thus vested in two-phase flow and pressure drop relationships. Flow instability may well result in severe fuel element damage, and it therefore becomes clear how important to water-cooled reactors is the research required to clear up the many gross uncertainties in two-phase pressure drop.

References

1. Mikhail, N. R. PhD Thesis, Univ of London, 1952
2. Jakob, M. *Heat Transfer* Vol 1, 1949
3. Durham, F. P. *Nucleonics* 1955, *13* (5), p 42
4. Gunther, F. C. and Kreith, F. *Heat Transfer and Fluid Mech Inst*, 1949, p 113
5. Gunther, F. C. *Trans ASME* 1951, p 115
6. Plesset, M. S. and Zwick, S. A. *J. App Phys* 1954, *25*, p 493
7. Forster, H. K. and Zuber, N. *J App Phys* 1954, *25*, p 474
8. Griffith, P. *ASME-AIChE* Heat Transfer Conference Paper 57-HT-2, 1957
9. Dergarabedian, P. *J App Mech* 1953, *20*, p 537
10. Ellion, M. E. *JPL Memo*-20-88, 1954
11. Forster, H. K. and Zuber, N. *JAIChE* 1955, *1* (4), p 531
12. Fritz, W. *Physik Zeitschr* 1935, *36*, p 379
13. Zuber, N. and Tribus, M. *AECU*-3631, 1958
14. Kozlov, B. K. *Zhur Tekh Fiz* 1954, *24* (12) p 2285 (*Trans ATS* 13G 7 R)
15. Lottes, P. A. *et al.* A/conf 15/P/1983, 1958
16. Nikuradse, J. *Forschung VDI* 1933, p 361
17. Rohde, R. R. Personal communication to Jens and Leppert, *J Am Soc Naval Engineers*, 1955, *67*, p 437
18. Wood, A. B. *Textbook of Sound* 3rd Edn, 1955, p. 360
19. Campbell, I. J. and Pitcher, A. S. *Proc Conf Admiralty-US Navy ARL Teddington*, 1954
20. Schwarz, K. *Forschung VDI* 1954, B20 No 445, p 1
21. Styrikovitch, M. A. and Kholodovskii, *Izvest Akad Nauk Otdel Tekh Nauk SSSR* 1951, 506; AEC Trans 1433
22. Martinelli, R. C. and Nelson, D. B. *Trans ASME 70*, 695 (1948)
23. Lockhart, R. W. and Martinelli, R. C. *Chem Eng Prog* 1949, *45*, p 39
24. Weiss, D. H. MSc thesis; results quoted by Isbin *et al AECU*, 2994, 1954
25. Sher, N. C. and Green, S. J. *Nuc Eng and Sci Conf*—Preprint 146, March 1958
26. Roberts, H. A. Unpublished work
27. J. W. Weil (Editor) *GER* 1468, 1958

Detection of radiation has now become a day-to-day activity in many industries and a variety of reliable, soundly-engineered instruments is now available. Here is the first article in a new series designed to help you choose the right detector for your particular application

by A. L. GRAY, BSc
Plessey Nucleonics Ltd

RADIATION DETECTORS

1—their operating principles

THE DEVELOPMENTS in the fields of nuclear physics and engineering over the past decade have led to a very great increase in the use of radiation detectors. Whereas at the end of the last war the production and use of nuclear radiation was essentially an activity of the research laboratory, where each problem in the detection and measurement of radiation could be considered from first principles by a specialist and the appropriate technique evolved, the application of nuclear radiation is now rapidly extending to industry. The problems of measurements are thus being met by a far wider circle of physicists and engineers who require solutions to their problems in the form of reliable, soundly engineered instruments, rather than the highly developed products of laboratory techniques which require specialized knowledge to apply and maintain them. In general the industrial scientist does not wish to become involved in the design criteria of radiation detectors but is more concerned with making the right choice of detector for a given measurement from those commercially available to him, and requires therefore to understand the merits and fields of application of each type.

It is therefore the purpose of this and the succeeding articles to review the range of radiation detectors available and to consider their application. This article describes the basic methods of detection as a background to a detailed consideration of detector characteristics.

Mechanism of detection

The radiations to be considered are of three different types: charged particles, protons, alpha particles, beta particles etc; quanta of electromagnetic radiation, i.e. gamma rays; and uncharged particles, neutrons.

The detection of these is accomplished by their interaction with matter to produce measurable changes in its physical or chemical properties. The fundamental mechanism of this interaction is the transfer of some or all of the energy of a charged particle to a suitable detection medium. As the particle traverses the medium its electric field couples with the field of the orbital electrons of the constituent atoms of the medium. The energy transferred to these atoms may ionize them or excite them above their ground state. Where the atoms are ionized free positive and negative charges appear, but where they are excited to a higher energy level they may decay again to their ground state, emitting the energy as a flash of light, or, if the energy transferred is sufficient, electrons may be raised to the conduction band to behave as free electrons.

The passage of a charged particle through matter may also produce changes which are of a more permanent character such as the condensation in a cloud chamber or the image on a photographic plate. Effects of this type, which do not yield a directly observable signal, will not be considered here.

The detection medium may be gaseous, liquid or solid, the first and last being most common. Where the medium is gaseous the passage of a charged particle leaves a track of ions and electrons. If left undisturbed these rapidly recombine but if subjected to an electric field they may be separated before this can occur and collected as a pulse of electric charge. Although ionization may be produced and collected in a liquid the collection characteristics are very unfavourable and liquids are normally only used as scintillation media, where the energy of the charged particle absorbed by the medium reappears as a flash of light. Solid detection media are also principally used as scintillators but may also be used as conduction counters. In this latter type the energy of the particle is absorbed by the lattice of a semiconducting crystal and raises electrons into the conduction band.

Where the primary radiation incident on the detector does not consist of charged particles, some intermediate process must be employed yielding secondary charged particles which may be detected in one of the above-mentioned ways. This process takes place in a reaction medium and for

the type of detector we are considering where an observable signal is required with a small time constant, the reactions chosen must be prompt ones. In the case of gamma radiation three different processes may be involved in producing the secondary particles, which are always electrons. For low energy photons the electron yield is due principally to photoelectric absorption in the medium, but at intermediate energies Compton scattering and, at high energies, pair production, are most important. In a detector with a gaseous detection medium most of the photon interactions occur in the walls and structure of the counter, but in a solid or liquid the medium itself usually acts also as the scattering or reaction medium.

For the detection of neutrons the secondary particles are produced by a nuclear reaction between the neutrons and the reaction medium. The most favourable reaction depends on the neutron energy and the preferred form of medium. For neutron detection these may be gases, liquids or solids, and in many cases may also be used as the detection medium itself or may be distinct from it in the form of foils, surface films etc.

The chain of events in the processes of detection are summarized in diagrammatic form in figure 1.

Gas ionization detectors

Detectors in which the detection medium is a gas form the majority of those in use at present. Such a detector usually consists of an electrode system enclosed in a gastight envelope, connexions to the electrodes being made through gastight lead-through seals. Many different geometrical arrangements are used, but figure 2 shows the essentials of a cylindrical detector. Where the detector is designed for photons or neutrons the secondary particles are produced inside the envelope and the provision of windows into the sensitive volume between the electrodes is not necessary. If however the detector is used for charged particles it is necessary to ensure that a window thin enough to allow them into the counter is provided. In the case of heavily charged particles, such as alpha particles whose range in matter is very short, this may not be possible and it may be necessary to arrange for the source of radiation to be inside the detector.

The dimensions of the sensitive volume are usually chosen together with the gas pressure so that as much of the energy of the particle as possible is absorbed between the electrodes. For beta particles which have very long ranges, e.g. 800 cm in air at NTP for a 2 MeV beta particle, this is not usually possible but with most other particles virtually complete absorption is possible.

TABLE 1 *Values of W_i and range for alpha particles in various gases at NTP*

GAS	W_i (EV)	RANGE OF 5·3 MEV ALPHAS (CM)[4]
air	32·1[1]	3·8
argon	24·9[3]	4·0
methane	27·4[3]	4·2
hydrogen	36·0[2]	18·2
boron trifluoride	33·3[1]	1·8
nitrogen	33·7[1]	4·0
carbon dioxide	31·2[1]	2·6

References

1. Dick, L. *Helv Phys Art* 1947, *20*, p 357
2. Gray, L. H. *Proc Camb Phil Soc* 1944, *40*, p 72
3. Schmeider, K. *Ann Phys* 1939, *35*, p 445
4. Taylor, D., and Sharpe, J. *Proc IEE* II *98*

TABLE 2 *Range and specific ionization for beta particles in air at atmospheric pressure*

ENERGY (MEV)	RANGE (CM)	S_t (ION-PAIRS/CM)
0·5	145	57
1·0	370	46
2·0	830	43
3·0	1250	41

Reference

Taylor, D., and Sharpe, J. *Proc IEE* II *98*

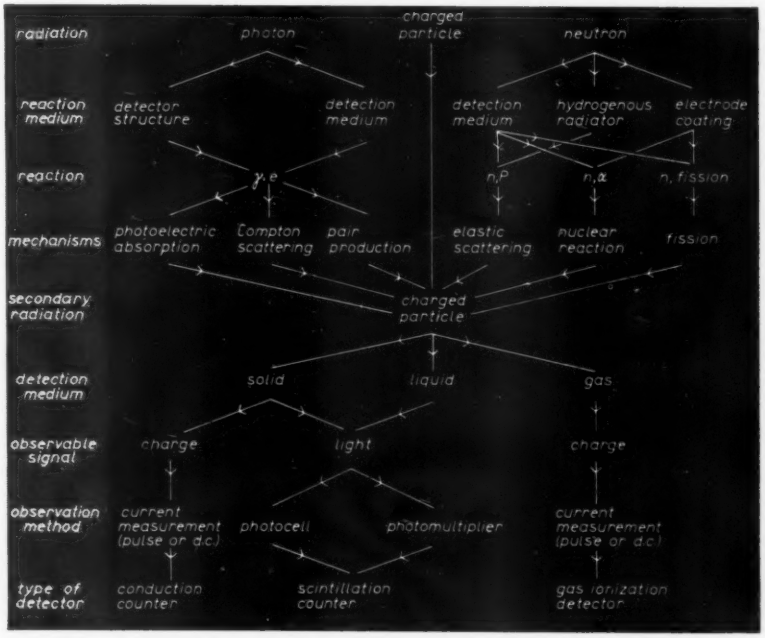
Most gases require an energy of about 30 eV to produce an ion pair at NTP. Thus if all the energy of the particle is absorbed the total possible charge which may be collected on the electrodes by means of an electric field is roughly $eE/30$ where e is the charge on the electron and E the energy of the particle in electron volts. Where the energy is not all absorbed, as for example in the case of a beta particle, the ionization produced may be calculated from the specific ionization, i.e. the number of ion pairs produced per centimetre of path at a pressure of one atmosphere. For electrons in air at NTP this is about 45 ion pairs/cm.

The collection of the charge represented by the ionization depends on the collecting field between electrodes in the way shown in figure 3. The two curves are shown for different particles producing different amounts of ionization, such as an alpha and a beta particle. At first, as the field is increased, the pulse size increases also as more of the ions produced are collected and fewer recombine.

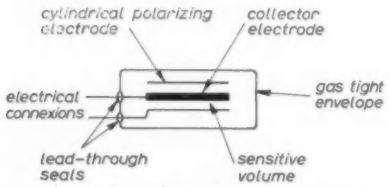
At a certain field, depending on the intensity of the ionization, all the ionization is collected and further increase of field produces no change of pulse size. This region is known as the saturation region, and detectors operating here are known as ionization chambers. The size of the voltage pulse on the collector electrode depends on the amount of ionization initially produced and the total capacity of the collector and input circuit of the measuring equipment.

At the upper limit R of the saturation region the electrons in transit to the positive electrode acquire sufficient energy to produce further ionization in the gas by collision. The collected pulse then includes these secondary electrons as well as those due to the prim-

Chain of events in radiation detection processes (Fig 1)



ary ionization, the ratio of total charge collected to primary ionization increasing as the field is raised. This ratio is known as the gas multiplication factor. The pulse size still depends on the amount of initial ionization and for a constant collecting field is proportional to it. A detector operated in this way is therefore known as a proportional counter and the pulse height provides an indication of the type and energy of the radiation. At its upper end the proportional region merges



A number of geometrical arrangements are possible in a gas ionization detector; these are the essentials of the cylindrical form (Fig 2)

with the transition region of limited proportionality ST beyond which the size of the pulse produced is independent of the initial ionization and depends only on the collecting field. The pulse then takes the form of a discharge triggered by the initial event and the detector operates as a geiger counter. Beyond the geiger region TU the discharge becomes continuous and the counter breaks down.

Ionization chambers

Ionization chambers are usually constructed with parallel plate or cylindrical electrode geometry so that the collecting field is as uniform as possible and the chamber shows a well defined saturation region. The collected pulses may be amplified and counted, or alternatively the chamber may be operated as a d.c. device and the rate of flow of charge to the collector measured as a current. D.c. use is more common since, unless the initial ionization pulse is very large, it may be lost in amplifier noise with the practically achievable input capacities.

For example, in the case of the alpha particles produced in the neutron reaction with boron

$$\text{B-10} + \text{n} \rightarrow \alpha + \text{Li-7} + 2{\cdot}4 \text{ MeV}$$

the maximum pulse height produced in an ionization chamber by a particle whose energy is completely absorbed is thus

$$V_p = \frac{Ee}{CW_i}$$

where E is the particle energy, e the electronic charge, C the total input capacity and W_i the energy required to produce one ion pair. Values of W_i for common filling gases are shown in Table 1. If the counter is air-filled at atmospheric pressure the value of W_i is 32 eV; hence V_p becomes about 50 μV for an input capacity of 250 pf. In fact, since only a small proportion of the particles are likely to end their path in the gas, most of the pulses will be smaller than this. In the case of a beta particle introduced through a window or produced by a gamma interaction where, say, 5 cm of path is in the sensitive volume, the pulse height is

$$V_p = \frac{ls_t e}{C}$$

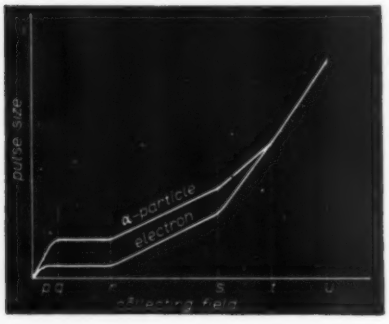
where l is the path in the gas, s_t is the total specific ionization for the appropriate particle energy and gas, and e and C are as before. For 1 MeV beta particles in air at atmospheric pressure (see Table 2) this gives a pulse size of less than 1 μV.

These are maximum pulse heights which may be obtained where both the electrons and heavy ions produced are collected. Although in practical geometries the electron may usually be collected in less than a microsecond, collection of the heavy positive ion which contributes to the charge takes up to several milliseconds. This means that individual pulses could not be counted at rates of more than a few hundred per second. Since the initial rise of the pulse due to the collection of the electron occurs in less than a microsecond, a short time constant in the amplifier may be used to reject the slow part of the rise so that the output is due to electron collection only. The full pulse height is not therefore obtained and the size of the electron pulse now depends on the distance the electrons have travelled to reach the positive electrode and is no longer unique to the amount of the initial ionization.

Since the charges are largely below the noise level of pulse amplifiers, ionization chambers are mostly followed by d.c. measuring systems. One notable exception to this general rule is in the use of an electron collection pulse chamber for neutron detection where fission reactions are used. The energy of the fission fragments is so great—about 160 MeV—that pulses of the order of 100 μv may be obtained.

The sensitivity of a d.c. ionization chamber may be estimated knowing the mean pulse amplitude due to an ionizing event and the rate of occurrence of the events. In the case of gamma radiation the current from a given sensitive volume may be estimated from the radiation dose in roentgens from the approximate relation that dose rate of 1 roentgen/h in free space in air at NTP produces a saturated current of 10^{-13} amp/cm^3. In a practical chamber this current will be increased by emission from the chamber structure and by the use of gases of higher atomic number at higher pressures.

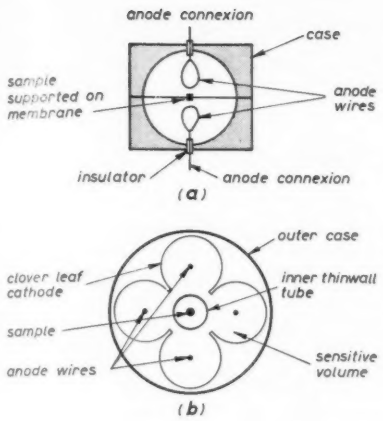
Dependence of pulse size on collecting field in a gas ionization detector (Fig 3)



Proportional counters

Proportional counters are constructed with anodes consisting of a thin wire, usually supported along the axis of a cylindrical cathode. This produces a very steep field gradient within a few diameters of the wire surface so that the multiplication of the initial ionization occurs in this region. This means that the great majority of the initial ionization occurs in the sensitive volume beyond this region so that electrons produced anywhere in the volume produce the same amount of gas multiplication. The pulse height is thus only dependent on the amount of initial ionization and the multiplication. Gains of the order of 1000 or more can be obtained so that pulses of tens or even hundreds of millivolts can be produced.

The relatively small pulses from electrons emitted by photon interactions with the walls may be rejected by a pulse height discriminator which only accepts pulses over a certain size so that such counters may be used to count particles in the presence of a gamma background. Where low energy or short range particles are to be counted it may not be practicable to use a window in the envelope and the source is sometimes placed inside the counter. In this case a trap is used to insert the sample and a continuous flow of gas passed through the counter, avoiding the necessity of pumping down each time the sample is changed. Such flow counters are often constructed with 4π geometry with the sample in the centre of the sensitive volume. The arrangement of such a 4π counter and of an annular counter for cylindrical samples is shown in figure 4.



For low energy or short range particles, flow counters with 4π geometry are often used, such as **a.** above, or the annular counter for cylindrical samples shown in **b.** (Fig 4)

Geiger counters

The construction of a geiger counter is very similar to a proportional counter. A metal or glass envelope with a separate internal cathode tube may be used. The envelope may have a thin end window of glass, mica or aluminium, or may have thin walls. For liquid samples counters are made with jackets. Typical arrangements are illustrated in figure 5.

The output pulse of a geiger counter is independent of the nature of the initiating event and may have an amplitude of several volts. Once the e.h.t. exceeds a threshold below which the counter does not operate, the curve of count rate against e.h.t. shows a long plateau on which the count rate varies very little with voltage. The pulse size does change, however, and it is normally preferable to limit the size of the discharge by working towards the lower end of the plateau in the interests of counter life. The nature of the discharge is complex but following it is a dead period during which the counter will not respond to ionization. This period may be between 50 and 500 μs according to the type of counter so that the count rate is limited to a few thousand per second at most.

If simple gases are used in these counters the production of secondary photoelectrons by the discharge prolongs it and may make it continuous. A quenching agent is therefore added to suppress the secondary discharge. A complex organic gas or a small quantity of a halogen may be used. Halogen quenched counters are used in many applications as they have very long lives and also very low threshold voltages.

Geiger counters do not permit of discrimination between different sorts of radiation. Their rather limited range may be extended by operation in a d.c. mode where count rates of a few thousand per second are exceeded.

Scintillation counters

The technique of observing scintillations in a suitable phosphor is a very old one and was originally used for counting alpha particles incident on a zinc sulphide screen. Its extensive use however awaited the development of the photosensitive electron multiplier tube which is sufficiently sensitive to produce a large output pulse from the very small light output of the phosphor.

The arrangement of a scintillation counter is essentially very simple, consisting of a suitable phosphor coupled optically by a transparent medium to the screen of a photomultiplier. The output pulses from the tube are then either counted by normal pulse techniques or integrated in a d.c. measuring system. In some cases where the radiation is very intense, such as the flash from an atomic weapon, the light output may be great enough to operate a photocell rather than a photomultiplier.

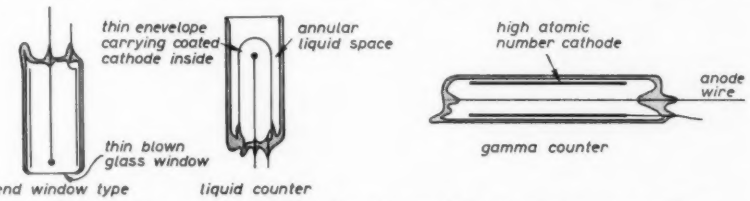
The limit of sensitivity is set by the noise level of the first stage of the photomultiplier and it is therefore most important that no light is lost from the phosphor. Good optical coupling and highly reflecting coatings on the surface of the phosphor are used and, wherever possible, highly transparent phosphors are chosen. The dimensions of the phosphor are chosen to absorb as much as possible of the energy of the incident particles. Where these are of short range, such as alpha particles, a thin screen of zinc sulphide crystals may be used, but for beta particles and for gamma rays, where the phosphor forms the reaction medium, phosphors up to several inches thick may be used. The condition of transparency is met in these cases by using large single crystals, solutions of phosphors in transparent plastics, or liquid phosphors.

For gamma-ray measurements the most widely used phosphors are thallium-activated sodium iodide crystals. These may be grown as clear single crystals up to several inches in size. They are unfortunately highly deliquescent and must therefore be hermetically sealed. They have a relatively high absorption coefficient for gamma radiation. For alpha particle detection polycrystalline layers of zinc sulphide deposited on thin aluminium foil are usually used. A number of organic materials form useful scintillators and have the great advantage of very short decay times whereas those of the alkali halides are relatively long. The low gamma absorption of organic phosphors however limits their use mainly to beta counters.

Plastic scintillators, which are solid solutions of organic phosphors in a plastic such as polystyrene, are used extensively for beta-particle detection since they are cheap to prepare and can be made as large as desired. Liquid scintillators may also be made by dissolving an organic phosphor in a suitable solvent, and are often used where a large bulk of phosphor is required.

Conduction counters

Conduction counters have been made with a variety of materials, notably cadmium sulphide, silver halides and diamonds. Their gamma absorption cross sections are high so that they make efficient detectors but there is normally considerable difficulty associated with their preparation as large single crystals and in most cases fatigue effects and lack of reproducibility have limited the use so far to certain special problems. The rapid progress recently made in the preparation of semiconducting materials, particularly the intermetallic (Group III–Group V) compounds, suggests that the useful properties of some of these materials may lead to the development of more satisfactory solid counters. Such counters are not yet commercially available however.



In typical geiger counter geometries, the envelope is metal or glass with a separate internal cathode tube (Fig 5)

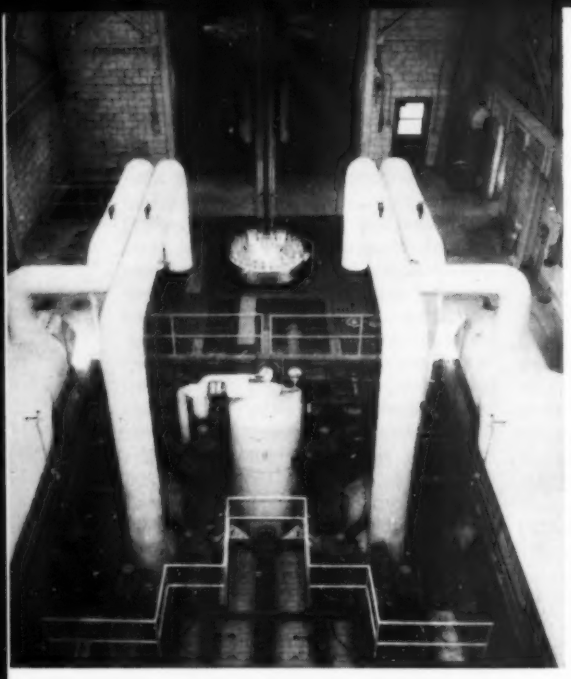
Bibliography

Korff, S. A. *Electron and Nuclear Counters* D. Van Nostrand

Currand, S. C., and Craggs, J. D. *Counting Tubes* Butterworth

Rossi, B., and Staub, H. *Ionization Chambers and Counters* McGraw Hill

Wilkinson, D. H. *Ionization Chambers and Counters* Cambridge



The reactor is located in a 23 ft deep pit. Nearer pit contains pressurizer and pumps but heat exchangers are on floor level to give some natural convection

SPERT III goes critical

Latest in a series of special facilities at the Idaho Test Station, it is designed to find out what happens during a sudden power surge in a pressurized or boiling water reactor

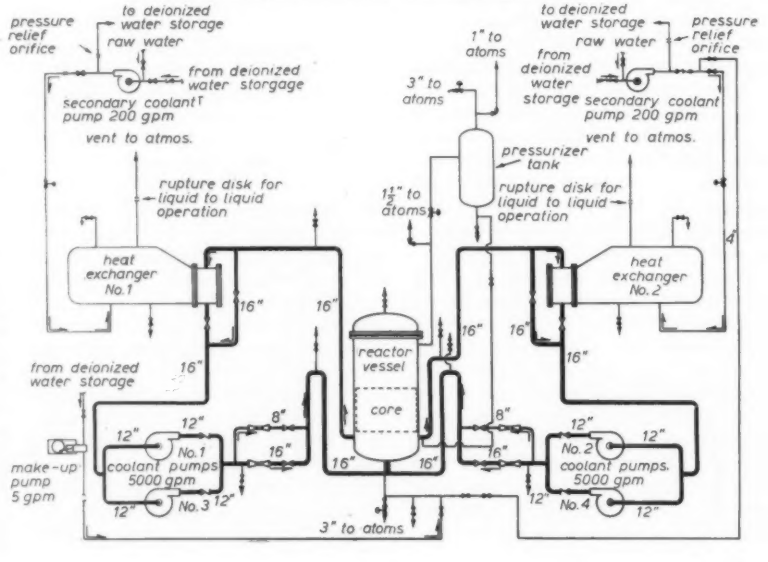
ANOTHER special-purpose experimental reactor has recently started up in the United States. This is the Special Power Excursion Reactor Test No 3 (SPERT-III) and criticality was first achieved in the new plant, situated at the AEC's National Reactor Testing Station in Idaho, at 11.47 p.m. (MST) December 19. The reactor was constructed for the Commission by Paul Hardeman, Inc, of Los Angeles, Calif; Phillips Petroleum Company furnished the conceptual design and Stearns-Roger Manufacturing Company, Denver, Colorado, accomplished the detailed design. Phillips is now operating the plant for the AEC. Total cost of the facility, including equipment, is approximately $3·5 million.

SPERT-III is one of a series of reactors designed and developed by Phillips, under contract with the AEC, as part of its programme for investigating reactor behaviour under runaway conditions. All operations are conducted remotely since tests approach reactor destruction. This facility provides the widest practical range of control over three variables—temperature, pressure, and coolant flow rate. The plant is expected to contribute significantly to a better understanding of reactor self-limiting and instability characteristics exhibited in more than 750 excursions in SPERT-I. This reactor, which began operation in July 1955, was the first of a series established to investigate potential hazards associated with the broad class of heterogeneous water-moderated, enriched-fuel reactors. The second reactor in the series, SPERT-II, is still under construction. It will continue the same type of studies initiated by SPERT-I but with special emphasis on how various moderators and reflectors, including heavy water, influence reactor behaviour.

Tests in SPERT-I, utilizing a simple open-tank system, are generally characterized by sudden power rises (one reaching $2·8 \times 10^9$ watts) that are arrested by the inherent shutdown or self-limiting tendency of the reactor itself. Without any external control rod manipulation, reactor power reaches a peak in a fraction of a second and drops off to much lower but generally steady levels. In some cases, however, instabilities also are observed following the power peaks. Some of these are divergent oscillations that probably could destroy the reactor, despite its self-limiting characteristics, if allowed to continue.

The precise causes of the self-limitation and power instabilities observed in SPERT-I are not known. It is in an effort to obtain a thorough understanding of these and other phenomena that the Commission has authorized a long-range basic research programme in which the major possible causes will be tested for verification.

The coolant system has two primary loops designed for 2500 psi, 668°F. Flow rates are adjustable from 200 to 10,000 gpm in each



This programme will require the continued operation of SPERT-I together with SPERT-II and III, and may entail future construction of additional reactors in this series.

A series of nuclear physics measurements leading to a special programme of reactor hazards studies is now being conducted in SPERT-III. Although it is classified as a high-pressure, high-temperature, light-water-moderated-and-cooled reactor, its versatility will enable the performance of transient tests under various initial conditions of pressure, temperature, and coolant flow. Pressures ranging from atmospheric to 2500 psi, and water temperatures from 68°F to 668°F are attainable. Coolant flow rates range from zero to 20,000 gpm, with heat removal capacities up to 60,000 kilowatts for a duration of 30 minutes. The reactor can be utilized, therefore, to investigate conditions applicable to many reactor fields, including both pressurized and boiling water power reactors.

The facility consists of a reactor vessel, a pressurizing tank, two primary coolant loops, including pumps and heat exchangers, and other necessary auxiliary equipment such as the secondary water system and the water testing system required for operating a reactor system of this type. The reactor and coolant system are remotely operable, from a control centre about half a mile away. Shielding has been limited to that which will permit work on the reactor to proceed following a short period of power operation.

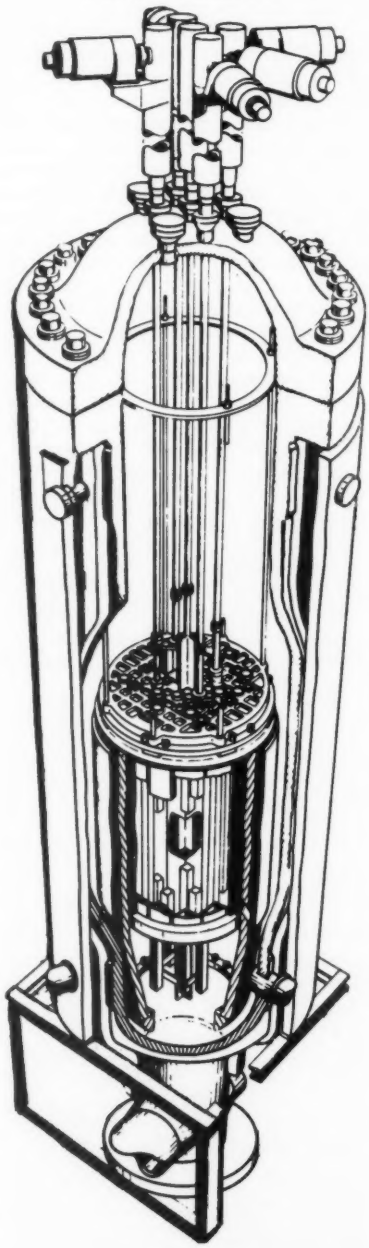
Flexible design

Investigation of various core arrangements is a feature of SPERT-III and the reactor vessel and control rod drive travel are sufficient to accommodate cores having a maximum active core height of 42 inches. The initial internal structure is designed to accommodate plate-type, stainless steel clad fuel elements positions being provided in the grid plates for a total of 68 fuel assemblies, including the fuel sections of the eight control rods. The four centre positions in the lattice are occupied by special small elements between which the cruciform transient rod operates. Other positions in the core take the standard assemblies, unoccupied positions being filled with hollow spacer-boxes. Surrounding the core is a $\frac{1}{2}$ in. stainless steel core skirt and four thermal shields ranging in thickness from $\frac{7}{8}$ to 2 inches.

The initial fuel elements consist of fuel plates, side plates, upper and lower end-boxes, and a centre reinforcing plate. The reinforcing plate has been added to increase the strength of the assembly and to minimize vibration of the fuel plates. To reduce pressure differentials in the core, the end-boxes are cut away, permitting the pressure inside and outside the assembly to equalize. The larger of the two sizes of assemblies is about 3 × 3 inches square, while the smaller is about 2·5 × 2·5 inches square. These assemblies contain 38 and 32 fuel plates containing 638 grams and 444 grams of U-235, respectively. Active core height is 36 inches. The fuel plates consist of a 93·5% enriched UO_2-stainless steel core 0·020-inch thick, clad on each side with 0·005 in. 304L stainless steel.

The reactor is fitted with four pairs of control rods and one transient rod. The control rods are the fuel poison type, containing fuel in the lower section and a poison material in the upper. The two rods in each pair are joined by a yoke and connected to the drive mechanism. In addition to providing the required control, this type rod was selected to minimize the number of rods in the core, thereby providing greater flexibility for the removal of instrument leads and experimental assemblies from the reactor core. The fuel section of each rod consists of 28 fuel plates identical to those in the 2·5 × 2·5-inch assembly, while the poison section consists of a hollow box made of an alloy of stainless steel and boron-10.

In the centre of core is seen the cruciform transient rod used to start power excursions



The transient rod is used for initiating power excursions. Located at the geometric centre of the lattice, it is of cruciform section and is guided in a square tube which also contains four fuel elements of the smaller size. In its normal position the poison section of the transient rod is below the core. When an experiment is to be performed it is raised into the core and the normal rods raised to bring the reactor just critical. The transient rod is then withdrawn according to the conditions of the experiment and the resulting power excursion studied.

Full-way core access

The reactor vessel has an inside diameter of 4 ft and an overall height of about 19 ft. Designed for a maximum operating pressure and temperature of 2500 psi and 668°F, it is capable of withstanding shock pressures up to 3500 psi. Laminated construction is used: 3 in. of mild steel with a $\frac{1}{2}$ in. internal cladding layer of 304L stainless steel. The bolted flanged head is a modified hemispherical forging giving full-way access for core changing.

Openings in the vessel head include five $1\frac{1}{2}$ in. dia. openings for the control rod drives, and four 6 in. access ports. These latter will be utilized for inserting and removing instrumented fuel assemblies, and for connecting the control rod drives. Access through the vessel wall is by six 4 in. access ports, five of which will be used for the removal of instrument leads and one for pressure relief. In addition, six 8 in. exit coolant water nozzles penetrate the shell. A flanged tee at the bottom of the vessel contains two 16 in. inlet cooling water lines, a drain and two 3 in. access ports. Five rod drive mechanisms are mounted on the vessel head. Four of the drives position the eight control rods, and the fifth the transient rod. Although the function of the two rods is somewhat different, the mechanical design is essentially the same.

1959
LONDON

PHYSICAL SOCIETY SHOW

Here is Nuclear Power's selection of the most interesting new developments arranged as a quick reference guide

INTEREST IN DEVICES giving a digital display is growing steadily, and last year's handful of exhibits has become a respectable family, with half a dozen new firms joining in. Racal showed a digital testmeter for measuring voltage, resistance and capacitance to an accuracy reading 0·1%, and their computer counter controller. Using only ferrite core and transistor techniques throughout the counting circuits it gives a four figure in-line display. Present range stops at 50 kc/s but the company intends to push it higher in future models. J. Langham Thompson unveiled a whole range of frequency meters (up to 100 kc/s), chronometers (down to 1 millisec intervals) and counters (up to 10 kc/s) all with neon in-line decade readout and provision for remote indication and printing units. Three firms who showed digital voltmeters in 1958 were back with improved techniques: Burndept, a 1 millivolt to 1000 volt d.c. instrument using four Nodistron tubes; Metropolitan-Vickers, high speed peak-reading voltmeter provided with an automatic reset which operates after a predetermined time interval—it then recycles and displays the value to be recorded; Solartron, a transistorized three window digital indicator for voltages from 0 to 999, black or red background illumination indicating polarity. An interesting attempt to axe the usual forest of electronics is being made by the British Physical Laboratories with a d.c. instrument using banks of relays which gives a three digit display in steps of 100 microvolts up to 99·9 millivolts. Two big companies—Ferranti and Ericsson Telephones—have moved in with a range of digital voltmeters and ohmmeters. Ericsson showed also their recently developed gas discharge readout tubes, which consist of shaped electrodes mounted one behind the other.

DIGITAL VOLTMETER
—Ferranti

Other digital display apparatus included an in-line rear-projection unit by R. B. Pullin giving one plane digit representation on a front viewing screen. Each unit provides for one digit 1 in. high from 0–9 and decimal points one before and one after the figure. Thorn Electrical Industries have developed two prototype edge-lit and electroluminescent display units, the first consisting of a stack of perspex plates engraved with numbers and lit by midget panel lamps, and the second giving numbers 0–9 by separate contacts by means of a special construction for the back electrode. The slow response of moving physical scales on galvanometers has been got round by the National Gas Turbine Establishment with the use of an optical projection of a digital scale in combination with a high speed photoelectric reader to make a digitized high speed galvanometer. Also by the Establishment: a Bourdon pressure gauge with circular digital scale instead of a pointer (9 bit-cyclic progressive binary code). Position of the scale is read photoelectrically.

The General Electric Co has been working on a digitizer for pointer instruments. The core and windings of the digitizer are mounted behind the meter scale, and the moving yoke, of thin light magnetic material, is mounted on the pointer; a 7-digit read-out unit for an 8 in. switchboard meter was on show.

Radiation detection

Ionization chambers Among the first showings was a new version by Labgear of the AERE 1453B gamma monitor. Four interchangeable ionization chambers for the six decade logarithmic amplifier and electrometer head amplifier now cover 0·1 mr/h to 10^6 r/h, and the instrument has a flexible pre-set alarm system. A new Ekco portable radiation monitor designed to meet the requirements of the impending Factories Act for beta and gamma radiation offers an integration facility of up to 30 millirads in addition to ranges of 0–3, 0–30 and 0–300 millirad/h. Another instrument from Ekco is a log gamma monitor for reactors which consists of an air-wall ionization chamber and amplifier head unit together with a rack-mounting main amplifier connected to it by up to 500 ft of cable. A true logarithmic range from 1 mr/h to 100 r/h is provided and the stability is said to be better than 5% of any decade over 24 hours. A log scaled gamma monitor by General Radiological has a 1 mr to 1000 r range and incorporates alarm signals and interlock circuits. Other reactor instruments included neutron detectors for high temperature operation (20th Century Electronics and Plessey). A new pocket geiger counter by Burndept uses a single transistor oscillator for tube e.h.t.

Fleming Radio have produced a radioactive version of their automatic air pollution monitor. A portable effluent monitor (also by Fleming) consists of a transistorized ratemeter and beta-gamma counter tube (immersion type, effective anode length of 10 cm) the base of which has been encapsulated so that it can be completely immersed. Total weight is 5½ lb and two ranges of count rate, 95 cps and 50 cps fsd, are displayed on a 2½ in. meter.

The ionization chamber in a prototype Avo remote indicator dose ratemeter is separated from its electronics and indicating unit by up to 15 ft of double concentric cable with new plug and jacket designs. The inner conductor carries the ionization current from the chamber, the inner braid is earthed to act as a guard ring, and the outer braid supplies the 20 volt polarizing potential. A 5 in. meter scale is employed to show 3½ decades from 0·1 to 500 r/h, on a logarithmic scale.

Scintillation counters A lightweight Ekco portable monitor (N 645A) is designed for tracing very small quan-

tities of any radioactive source. The watertight scintillation counter can be fitted with a range of phosphors for alphas, betas, gamma rays and slow and fast neutrons. A 4 ft lead connects the probe to the main ratemeter which is transistorized and battery operated. A universal form of scintillation counter for the evaluation of beta particle activity has been developed to the prototype stage by Labgear. The unit comprises an 11-stage photomultiplier and dynode chain in a lead housing with access to the photo-sensitive cathode at the top of the shielding. A number of attachments allow both planchets and micro-beakers in conjunction with plastic phosphors of slab or well-type shapes to be accommodated, and liquid scintillators and scintillating gels can be used, as well as a zinc sulphide screen for the detection of alpha particles. The unit is readily adaptable to gas counting by the addition of a suitable chamber. A tritium counter demonstrated by Hammersmith Hospital has an efficiency quoted at 30% with a background of 60 c/s and is used for samples of tritiated setroids and counting sample of tritiated water (at somewhat lower efficiency).

Radiation counting

The Harwell-Ericsson Telephones type 2000 unitized counting equipment has been developed to cover a range of applications from reactor pulse channel counting to simple halogen quenched geiger tube counting.

The Ekco N600A ratemeter gives a complete spectrum analysis facility with a discriminator unit which has an automatically or manually swept single channel with a range of fixed or proportional gate widths, some narrow enough to scan and resolve gamma spectra, others wide enough to select a given peak and so improve signal to noise ratio in conventional counting of known sources. Integration is provided in the form of a mean probable error control, the circuit of which maintains the mean probable error constant by automatically adjusting the time constant inversely to the count rate. Resolutions: 3 microsecs. The Isotope Developments 1700 scaler is now in its final production form. Incorporating automatic pre-set count and timing facilities it forms a self-contained counting equipment.

A simple prototype scaler by Panax consists of two plug-in Dekatron stages followed by a resettable mechanical register giving a total count of 999,999. Resolving time of the scaling circuits is 300 microsecs and maximum count rate for regularly spaced pulses determined by the mechanical register reaches 120,000 cps.

The use of vibrating-reed electrometers with ionization chambers to overcome the impedance and stability disadvantages of conventional amplifiers continues to increase. The Ericsson type 126A, developed from a Harwell design, offers an impedance of more than 10^{14} ohms and can measure currents of 10^{-16} amp. This instrument should find further employment in pH and mass spectrometry applications. Electronic Instruments, one of the first in this field, show an electrometer designed for use with ionization chambers—a battery operated instrument capable of detecting 10^{-10} amp with a time constant of less than 25 millisecs—as well as a mass spectrometer amplifier developed on behalf of the AEA which uses a Vibron unit operating at 800 cps. Another vibrating reed electrometer providing ranges of 3 mV to 3 V at input resistances of 10^{8}, 10^{10} and 10^{12} ohms has been made by Ekco.

Nucleonic gauging

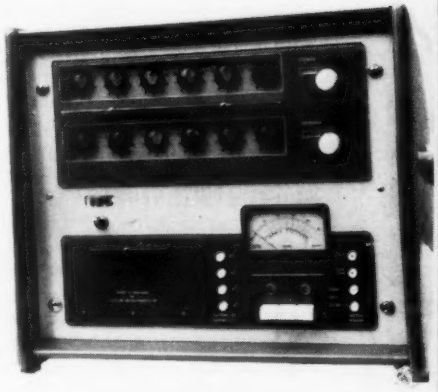
Miscellaneous nucleonic instruments included a portable transistorized thickness gauge by Burndept. Backscatter techniques are employed and a beta active source is used in conjunction with end window geiger tubes. Baldwin Instruments are making an automatic standardizing unit for their Atomat thickness gauges. The fast responding Atomat has a lag of less than 0·1 sec and with special low capacity lead cable this can be brought down to 0·04 secs. A portable transistorized density gauge (Cawkell Research & Electronics) uses a source of gamma radiation, a geiger counter and scaler for dealing with a variety of materials in bulk. Curves are provided so that density can be read off from count after allowing for background radiation.

Pulse techniques

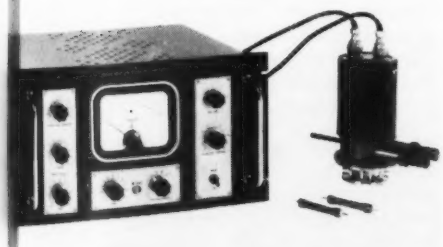
New pulse generators included one designed by Sunvic for their prototype 100-channel pulse height analyser (similar to the Mullard L332 described on p 508, October '58). Overall amplitude stability is better than ±0·05% over an 8 hour period allowing for ±5% mains variation, say the com-

RATEMETER
—Ekco

SCALER
—Isotope Developments

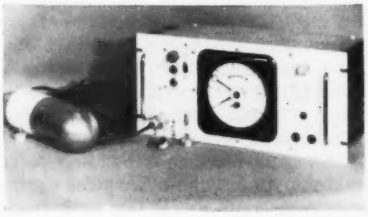


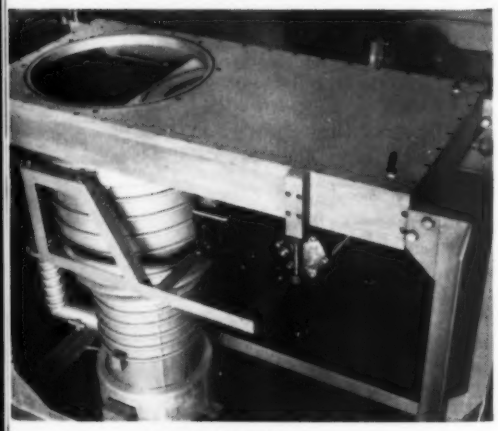
MASS SPECTROMETER AMPLIFIER
—Electronic Instruments



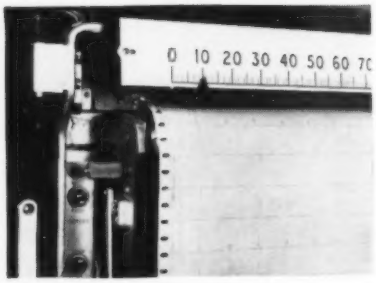
SELF-STANDARDIZING ATOMAT
—Baldwin Instruments

GAMMA MONITOR
—Labgear

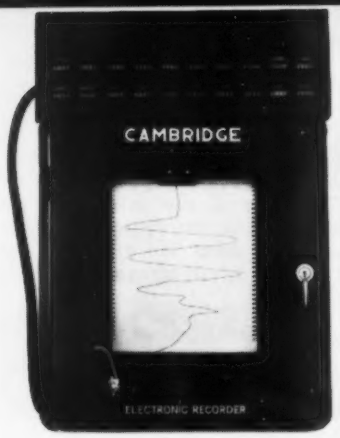




PUMPING GROUP
—Edwards High Vacuum



INTEGRATING RECORDER
—Sunvic



AUTOMATIC CHART ANALYSER
—Cambridge Instruments

TAPE READER
—Elliott

pany. The new Wayne Kerr short duration type P131 gives seven widths from 0·05 to 1 microsec at recurrence frequencies of 50–50,000 per sec internal and 1 to 50,000 external. Rank Cintel's delayed pulse and sweep generator has been further developed and now offers a double pulse continuously variable from 0·09 microsec to 105 millisecs and up to 50 volts amplitude as well as the 8 volt 40-microsec wide prepulse and variable single pulse. Other outputs include single and double sawtooths coincident with the main pulses and a cable-formed pulse derived from the main pulse. Period is variable from 0·9 microsec to 1·05 secs, delay from 0·09 microsec to 105 millisecs.

The square waveform of the 5002 Nagard Double Pulse Generator has been improved, and the accuracy of both delay (0·2 microsec to 2 secs) and width calibration when set for the production of two consecutive pulses is better. Racal demonstrated a Digital Pulse Delay generator built up from standard plug-in units to generate precision delays between input and output pulse in the range 3 microsec to 1 sec with an accuracy of ±1 microsec and showed a selection of transistorized logical blocks for building pulse systems. Among the other pulse equipment was a 10–50 kV fast peak reading voltmeter developed for the AEA by Wayne Kerr which can cope with positive going pulses down to 1 microsec duration with an accuracy of 5%.

Data processing and computing

A prototype automatic chart analyser (Cambridge Instrument Co) automatically samples a recorder chart at intervals of 1 mm to determine the percentage of a recorded quantity which falls within given limits. A servomotor keeps a photoelectric 'line detector' on the trace and also operates a series of limit switches feeding counters; these correspond to the intervals between the limits and they are fed with pulses at a rate of one for each millimetre of chart, each pulse raising by one digit the counter in whose section the record trace falls at the time. The outputs of up to 24 thermocouples can be displayed in the form of a profile on a cathode ray tube by a Distillers Company scanner, with a time period of $1\frac{1}{2}$ secs.

A new type of storage element under development by the Royal Radar Establishment consists of a superconducting surface carrying a persistent current inductively 'set-in' by control pulses and afterwards inductively 'read.' In principle reading and switching times could be well under 10^{-7} sec.

Punched paper tape readers capable of handling up to 1000 characters a second were shown by Elliott Brothers (London) and Ferranti. Elliott's is a Cambridge University design and in spite of its speed can stop on a single character. Transistor counting and arithmetic units on printed cards by Ericsson Telephones operate from +6 V, −6 V and −12 V power supplies and are claimed to withstand ±30% variations provided the changes are applied symmetrically. New printed circuit d.c. amplifier and corrector units for a version of the Elliott Miniac computer have reached the prototype stage; the combined unit has a drift of less than 100 microvolts. An apparatus for measurement of very small time intervals (Research Institute of National Defence, Sweden) gives a new twist to an old idea by using two condensers instead of one to eliminate errors due to voltage variations and losses in a single condenser. The charging ratio between the two is taken as an indication of the time and is measured by the impulses from a glow lamp oscillator which is used to smooth out the unbalance.

Vacuum, pressure and flow

A prototype of a pumping group similar to the type selected for the 7 GeV proton synchrotron under construction at Harwell by Edwards High Vacuum. The high speed oil diffusion pump is fitted with refrigerated chevron baffle and full bore gate valve on the high vacuum (inlet) side and is backed by a mechanical pump. Control of the two pumps, gate valve, baffle and backing valve is entirely automatic.

Spacing between the orifice and diaphragm of a gas valve shown by the Low Temperature Research Station is varied photoelectrically by the height of a column of liquid in a manometer to control flow. In a Lintronic differential pressure gauge the dynamic axial movement of the diaphragm is counter balanced by a solenoid whose working current is controlled by a transistorized feed-back amplifier deriving its error signal from the linear transducer. The diaphragm of the gauge is in effect static with respect to the differential pressure and the control current is linearly proportional to flow velocity.

Metals and materials

Efforts to produce graphite impermeable to gases at high temperatures—very important for the UK reactor programme—look like being success-

ful. Two methods have been developed at the Royal Aircraft Establishment, Farnborough (see *Nuclear Technology* this issue) and were illustrated at the Exhibition. Reductions in permeability to air by a factor of 10^6 have been achieved. The General Electric Company demonstrated a graphite tube containing carbon dioxide under pressure being heated by an electric current to almost 600°C without leaking. Work continues on plutonium and the Atomic Energy Authority showed a method of studying specific heat changes with temperature. A specimen is supported on quartz points in a spherical furnace and adiabatic conditions are maintained by automatic control of temperature to within 0·1°C of that of the specimen. The self heat generated by alpha emission is used as a uniform source and the specific heat obtained by measuring the rate of change of temperature of the specimen.

Copper-on-glass printed circuits by G. V. Planer aroused considerable interest. One example was a multiple layer inductor in which each glass plate carried a printed coil pattern on either side. Advantages claimed: suitability for high temperature operation, and inertness due to the absence of organic substrate or bonding constituents.

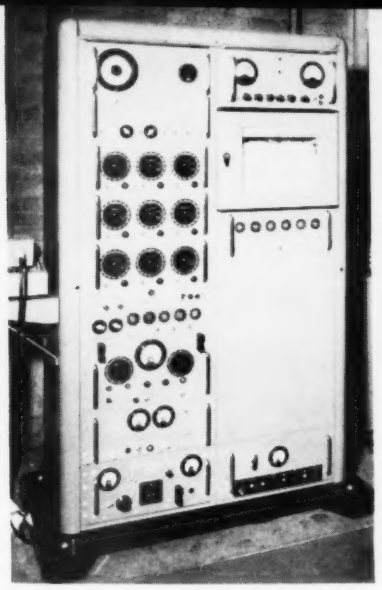
A new type of zone refiner for purification of metals and other materials (National Research Development Corporation stand) employs electron bombardment on a narrow zone of a rod in vacuo to produce concentrated heating and melting.

Analysis

First production model of the Fairey Nuclear Magnetic resonance spectrometer. Resolution of 1 to 2 parts in 10^7 over a sample volume of 0·05 cc has been achieved with a comparatively small magnet and the instrument is extremely compact. The 4 in. dia pole (0·72 in. gap) magnet gives a field strength of 4500 gauss. Resonant frequency of the nucleus under investigation is selected by a single tuning control and crystal stability is maintained over the full frequency range of 1–20 Mc/s. Both this and the Mullard instrument use temperature stabilization control for the magnets. The Mullard spectrometer is a bigger job: the 6 in. dia pole (1·25 in. gap) magnet has been redesigned to give a field strength of about 9000 gauss, and resolution of a few parts in 10^8 is claimed.

An experimental X-ray Microanalyser by Metropolitan Vickers Electrical enables chemical analysis to be carried out with volumes as small as 1 cubic micron employing the technique developed in France by Castaing. The Solartron X-ray fluorescence spectrometer shown last year has been improved by provision of a vacuum path to extend scope to elements of lower atomic number than 20 and the substitution of scintillation counters for geiger tubes to increase sensitivity in relation to counting time.

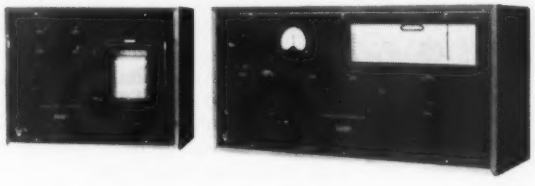
An infra-red gas analyser competitive with the Luft type of instrument but employing some dispersive system has obvious advantages. Sir Howard Grubb Parsons and Co have completed a prototype fixed wavelength analyser using a diffraction grating. Sampling and cleaning apparatus for gas analysis systems (Infra Red Development Co) include a gas flow regulator to provide a flow rate of 1 litre/min ±3% for applied pressures varying between 100 and 400 mm Hg positive or negative.



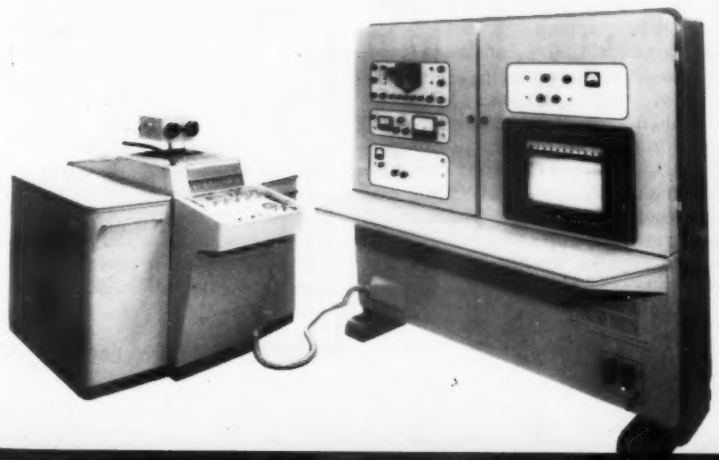
FLUORESCENT SPECTROMETER
—Solartron

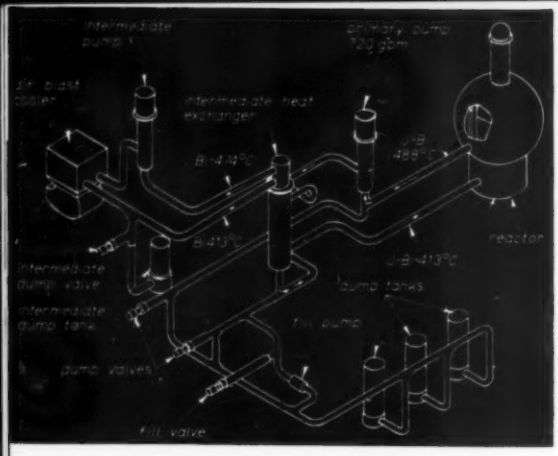
An alternative to the conventional dropping mercury electrode used in polarography is offered by Mervyn Instruments (design by the Water Pollution Research Laboratory). With a very wide bore, it reduces blockages, enables a continuously flowing liquid to be monitored, and provides a large and steady current for a constant concentration of reducible ions in solution. Harwell have developed their Linear Sweep Cathode Ray Polarograph to the Differential Cathode Ray Polarograph. Loss in sensitivity when carrying out derivative polarography using single cells has been overcome and the instrument now makes provision for measuring the difference in current between two cells.

Most interesting of the chromatographic apparatus were two Baird and Tatlock prototypes. One separates compounds by applying a continuous flow of solvent to a revolving disk of filter paper—average development takes only 6 minutes—and the other employs nitrogen hydrogen or helium as the carrier gas in a bench type instrument for gases and is capable of operation at temperatures up to 250°C. An integrating recorder for use with gas chromatographs (Sunvic Controls) employs an integrating motor powered from the slidewire of a potentiometric recorder and driving two shafts, contacts on which are used to apply potential to two solenoid-operated pens.



NUCLEAR MAGNETIC RESONANT SPECTROMETERS
—Fairey (left)
—Mullard (below)





After two years' concentrated work on its AEC assignment, Babcock & Wilcox are now preparing to build a critical facility for the LMFRE at their laboratory in Lynchburg, Va

Liquid metal fuel reactor experiment

by HUSTACE H. POOR,
Project Manager, Babcock & Wilcox Co, USA

ONE OF THE MOST promising of the advanced power reactor designs being developed by the USAEC is the Liquid Metal Fuel Reactor, LMFR. Studies of this concept have been under way at Brookhaven National Laboratory on Long Island, New York, since 1947, and a large amount of experimental work has been performed to obtain information on materials and components for use in this type of reactor. In 1955, the AEC set up an evaluation team of eighteen industrial organizations, under the leadership of the Babcock & Wilcox Company, to conduct a feasibility study of the concept at Brookhaven and it was their opinion that the LMFR did, in fact, show promise as an economical electric power producer. After considering the team's recommendations, the AEC issued a request for proposals to do research on, design, fabricate, erect, operate, and test a liquid metal fuel reactor experiment—LMFRE. A prime contract to perform this work was awarded to B & W in November 1956, and an intensive review of LMFR economic possibilities early this year, on the basis of much more information than was available in 1955, has confirmed that a large scale plant should produce electric power at a lower cost than any of the reactors presently under construction, perhaps at lower cost than any of the other advanced concepts now being actively pursued.

First system U-Bi

The LMFR concept comprises a combination of fissionable material and a liquid metal which serves both as fuel and as a reactor coolant. Many variations of this concept are possible; however, for the first experimental reactor the fuel will be uranium-235 dissolved in liquid bismuth. This solution will leave the reactor at 488°C, pass through a pump and heat exchanger, and return to the reactor at 413°C. In passing through the graphite core of the reactor the solution becomes critical, generating the heat which raises the uranium-bismuth solution to 488°C. The 5000 kWt thus generated are transferred to liquid bismuth containing no uranium in a heat exchanger, and the heat is then transferred to the atmosphere through an air-blast cooler. The intermediate bismuth coolant is provided so that the remote possibility of a leak in the primary uranium - bismuth system would not discharge radioactive material into the air stream.

High temperature operation

Some of the advantages inherent in the LMFR concept which make it particularly attractive are the following:

a. Operation at high temperature, and therefore the possibility of high efficiency, without high pressure in the reactor. The absence of high pressure is a safety and cost-saving feature.
b. No fuel elements, which are difficult and expensive to fabricate and instal are required; fuel replacement is easily handled by pumping
c. A large scale LMFR can be designed to breed. This means that a fertile material, such as thorium, can be exposed to neutron bombardment at such a rate that it is converted into a new fissionable material faster than the original fissionable uranium is consumed. The reactor therefore generates more fuel than it uses up.
d. This type of reactor is simple to construct.
e. Chemical processing of the fuel stream to remove fission products which hinder the nuclear reaction can be done continuously and cheaply.
f. Bismuth does not react violently with air or water, as do the materials used in some other reactors.

Disadvantages include the following:

1. Bismuth has a high melting point (271°C), and therefore an auxiliary heating system is required for startup
2. The highly radioactive products of nuclear fission are generated in the fuel stream throughout the primary system. As a result, a large proportion of the maintenance or repair work on this system must be performed remotely. Of course, the entire primary system must be absolutely leak-tight
3. Bismuth attacks many metals, and therefore only selected alloys may be used to contain the bismuth-uranium fuel stream
4. The amount of uranium which can be dissolved in bismuth is limited and therefore highly enriched, rather than natural, uranium must be used.

Two years' work by B & W

In the two years that B & W has been working on its assignment, the following work has been undertaken:

a. Two conceptual designs of experimental reactor facilities, one which would generate 20,000 kWt and one for 5000 kWt. The second, which is both smaller and simpler than the first, has been selected for detail design and construction
b. Comprehensive economic evaluation of several large scale power plants, confirming that the LMFR is one of the most economically attractive reactor concepts presently being considered
c. Research and development work at the B & W research centre at Alliance, Ohio, and with numerous subcontractors with major emphasis on corrosion of materials by bismuth, solubility of uranium-bismuth, remote welding of pipe, investigation of slurries of insoluble uranium compounds in liquid bismuth, and prototype testing of components such as valves, bellows, pumps, and instrumentation
d. Design and fabrication of two complex liquid bismuth circulating loops which will be installed in the Engineering Test Reactor and the Materials Testing Reactor at AEC's National Reactor Testing Station in Idaho to obtain information on the performance of LMFR materials under radioactive bombardment. B & W assisted BNL in the construction of a similar liquid bismuth circulating loop which will be installed in the 25,000 kWt research reactor at Brookhaven.

A control rod position indicator

by A. W. FENTON, A.M.I.E.E., *U.K.A.E.A., Capenhurst*

IT IS ESSENTIAL to know the position of the control rod in a reactor at all times; in particular, in an experimental reactor, it is desirable to measure very small changes in position. With a sealed sodium-filled reactor running at high temperatures, however, normal measuring devices cannot be used, and it is necessary to have a way of detecting the position of each rod which does not depend on inference from its own operating mechanism. The instrument described here, based on the principle of variation of electrical inductance, gives a remote indication of the position of the rod within the sealed reactor.

Designed primarily for use in the fast reactor at Dounreay, it can well be applied to any similar sealed reactor which demands remote indication. The principle of operation has been established, and a full-scale working model was first demonstrated at the Physical Society Exhibition in 1957. The design is the subject of a patent application (A. W. Fenton, 1957: Provisional Application 1574/57—*Control rod position indicator using transducers*).

The instrument has been designed to operate in a confined space at temperatures up to 300°C, and it is inaccessible when the reactor is in service. The control rod moves vertically and is provided with an extension piece. On this rests a ferromagnetic plunger, moving vertically and making a loose fit within a stainless-steel tube which forms part of the pressure shell of the reactor. On the outside of the tube is a coil system; the movement of the rod, and hence of the plunger, causes changes in inductance in the coils, which give the measurements of rod position.

Coarse and fine indications are given remotely on a panel, calibrated over 25 in. and 0·6 in. respectively. The fine indication acts as a vernier on the coarse, but the two measuring systems are separate electrically, and each can function independently should the other fail.

Coarse measurement

The coarse transducer is a form of the so-called 'differential transformer.' It consists of a long solenoid C_1 and a second, short solenoid C_2, each with a primary and secondary winding, as shown in figure 1. The length of C_1 is approximately equal to the total plunger travel. The primary windings of the two solenoids are connected in series and are energized from a mains-frequency source.

As the plunger P rises from its lowest point, the mutual inductance between the primary and secondary windings of C_1 increases, resulting in a similar increase in induced secondary voltage; the secondary voltage of C_2 which always contains the plunger, will remain unchanged. The ratio of these two secondary voltages is a function of the plunger position. This ratio, and hence the plunger position, is measured continuously by a self-balancing potentiomenter mechanism, the position of the potentiometer slider CS being transmitted to the remote indicator by means of a synchro repeater CR.

The use of a bridge form of measuring circuit minimizes the effects of temperature and mains supply variations of the accuracy of the readings.

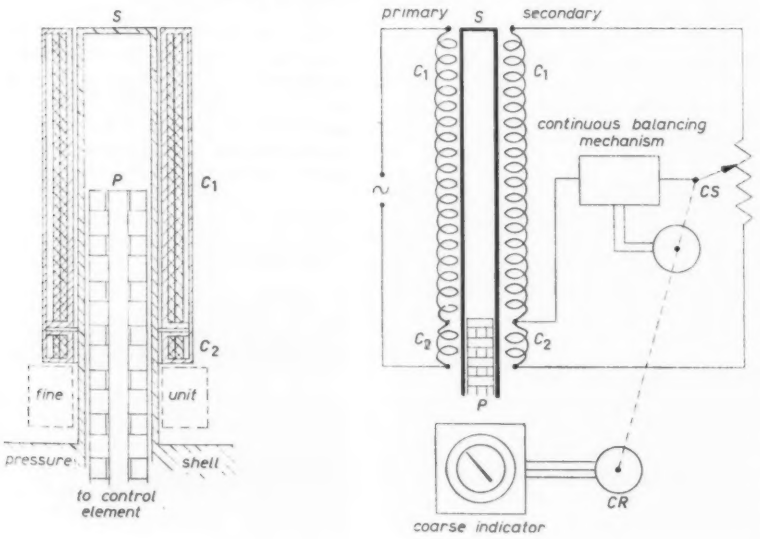
Fine indication

The fine transducer is formed by three flat iron ring yokes F_1, F_2, F_3, each with two salient poles, as shown in figure 2. The yokes are spaced along the central tube S and a common primary winding embraces one pole of each yoke; the remaining poles carry separate secondary windings.

The main plunger has a series of annular iron collars spaced 0·6 in. apart along its active length. As each collar traverses the transducer system, the reluctance of the gap at the poles of any one yoke will vary between maximum and minimum values. This causes the rms value of the induced voltage at the secondary winding to fall and rise in cyclic fashion. The length, spacing and diameter of the collars are such that the cyclic variations are sinusoidal about a mean value, the sine function making one complete cycle each time the plunger is displaced through one collar 'pitch' of 0·6 in.

The yokes are displaced along the tube S by one-third of a collar 'pitch', so that the sinusoidal voltages generated by each of the three secondaries have a relative amplitude phase displacement of 120°. It can be shown

Coarse control rod measuring system (Fig 1)

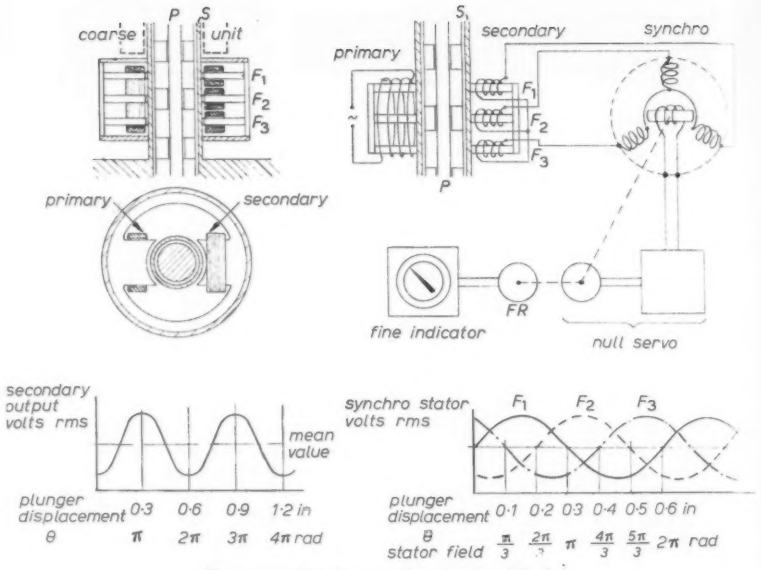


that three such equal-amplitude sine functions of a variable, θ, may be resolved into a single vector of constant magnitude at an angular displacement θ. Such a resolution may be performed by a synchro, a device which employs this principle for transmitting angular information. The three secondary voltages are applied to the synchro's stator windings, the resultant field of which is thus determined by the position of the collars in the transducer. This field rotates through 360° for a plunger travel of one collar 'pitch', i.e. 0·6 in.

The angular position of this field is followed by the synchro rotor by means of a null-seeking servo mechanism. This drives the rotor to the position of minimum induced rotor winding voltage, i.e. to an angular position displaced 90° from the resultant stator field. The angular position of this rotor is transmitted to the fine indicator by a synchro repeater FR.

In effect, the fine transducer is a linear form of synchro. Its operation is that of a true vernier, in that it has no cumulative error for any degree of plunger displacement other than that introduced by the tolerances on the mechanical dimensions of the collars and spacers.

The pitch and axial length of the collars, and hence the resolution and accuracy of the device, are determined by the radial gap between the collars and poles of the yoke. In this instance the total radial gap is 0·1 in. and the resolution 0·002 in.



Fine control rod measuring system (Fig 2)

Performance

The accuracy of the coarse measurement is ± 1% of the travel, namely ±0·25 inches in 25, and the calibration is nearly linear except at the extremes of the range. The accuracy of the fine measurement is ± 2% of the collar 'pitch', i.e. 0·012 inches in 0·6, and the calibration is linear. By correlation of both coarse and fine readings an overall accuracy of ± 0·05% of travel is obtained.

Acknowledgement

This paper is published by permission of the Managing Director of the Industrial Group, United Kingdom Atomic Energy Authority.

Nuclear Technology | Materials

Production of impermeable graphite

by W. WATT, R. L. BICKERDIKE, A. R. G. BROWN, W. JOHNSON and G. HUGHES,
Royal Aircraft Establishment, Farnborough

TWO PROCESSES for the production of graphite with a very low permeability to gases have been invented (*1*) at the Royal Aircraft Establishment. Graphite tubes treated by these processes retain their impermeability at high temperatures since the pore filling material is carbon itself. This opens up an entirely new field in the technological applications of graphite materials since the intrinsic high thermal conductivity, when allied with impermeability, makes possible the use of high temperature heat exchangers made of graphite. These low permeability graphites may be of particular importance in the atomic field, especially for the high temperature, gas-cooled reactor systems where retention of fission products is of prime importance. They will also have applications in the chemical and metallurgical industries, for example as impermeable crucibles, heat exchangers, or electrodes, where a reduction in porosity, increase in strength, and improvement in oxidation resistance may result in longer life.

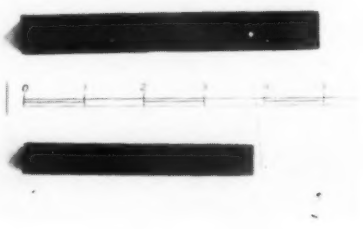
Furfuryl alcohol impregnation process

Furfuryl alcohol, $C_5H_6O_2$, when treated with a suitable catalyst polymerizes into a solid resin which, on carbonization, gives a 50% yield of carbon. During carbonization the resin shrinks uniformly without going through a liquid phase to give a carbon of density about 1·3 g/cm³. This is a non-graphitizing carbon obtainable in massive form which we have termed carbon glass (figure 1). Use has been made of these facts to produce impermeable graphite tubes by the following processes.

The graphite tube is impregnated with furfuryl alcohol plus a catalyst from one side only in the first stage. The resin is cured *in situ* and the tube carbonized to at least 1000°C. It is then reimpregnated from the other wall and the curing and carbonizing treatment repeated as before.

The tube may be subjected to a higher temperature treatment at this stage with no marked increase in permeability. It is therefore possible to start with a carbon material so that graphitization may be done after two impregnations. The process can be made very simple as pumping with a

Sample of furfuryl alcohol resin showed a shrinkage of over 20% on carbonization to 1000°C (Fig 1)



rotary pump followed by raising to atmospheric pressure can be used for the impregnations. The object of giving the tube two treatments in this manner from opposite walls is to overcome bursting on carbonization which happens if all the pores are filled with resin in one operation. The process is most effective with fine grained starting materials, and has been developed mainly for use with one particular industrial graphite. However, with suitable variations it may be adapted to other grades. The second impregnation may be done under pressure with an additive in the furfuryl alcohol to lower the surface tension. This is to assist penetration of the alcohol into the pores which have been made smaller by the first impregnation. Typical results are given in the table.

The processes described above have been scaled up by the Hawker Siddeley Nuclear Power Co Ltd, Slough, and 6 foot long tubes have been successfully treated. The bend strength of graphite materials thus treated is doubled.

SIZE OF TUBE	INITIAL PERMEABILITY TO NITROGEN AT ROOM TEMPERATURE cm^2/s	TREATMENT	PERMEABILITY TO NITROGEN AT ROOM TEMPERATURE AFTER TREATMENT cm^2/s
1 in. o.d. ½ in. i.d. by 3in. long	$2{\cdot}7 \times 10^{-3}$	*Two impregnations with carbonizing to 1000°C*	1×10^{-7}
,,	$2{\cdot}7 \times 10^{-3}$	*Two impregnations with carbonizing to 1000°C followed by heating at 2500°C for 1 hour*	$7{\cdot}2 \times 10^{-7}$
,,	$4{\cdot}8 \times 10^{-3}$	*Two impregnations with carbonizing to 1000°C followed by heating at 1800°C in vacuum furnace for 1 hour*	$6{\cdot}4 \times 10^{-7}$
2¼ in. o.d. 1½ in. i.d. 6 in. long	$2{\cdot}8 \times 10^{-2}$	*Two impregnations with carbonizing to 1000°C*	$2{\cdot}1 \times 10^{-6}$
,,	$1{\cdot}4 \times 10^{-2}$	,,	$5{\cdot}3 \times 10^{-6}$
,,	$1{\cdot}4 \times 10^{-2}$	,,	$4{\cdot}6 \times 10^{-6}$
2½ in. o.d. 1½ in. i.d. 6 in. long	2×10^{-2}	*Impregnated at atmospheric pressure, carbonized, then given a pressure impregnation treatment followed by carbonizing to 1000°C. This tube was then outgassed for 2 hours at 1000°C in vacuum of 2μ. It lost 0·03% by weight and the permeability was unchanged*	$1{\cdot}6 \times 10^{-6}$

Carbon cement

The furfuryl alcohol resin can be used to form an impermeable carbon joint between two pieces of graphite

Impermeable joint in this tube was formed by using furfuryl alcohol resin and carbonizing to 1000°C (Fig 2)

or carbon. The mating surfaces are suitably glued together with the resin and the whole cured and carbonized (figure 2). The joint is strong and impermeable and can be heated to 2800°C with no apparent change in its strength or permeability. The specimen tube with the joint shown in figure 2 had a permeability of $3{\cdot}4 \times 10^{-6}$ cm^2/s even after outgassing 2 hours at 1000°C.

Furfuryl alcohol carbon as binder

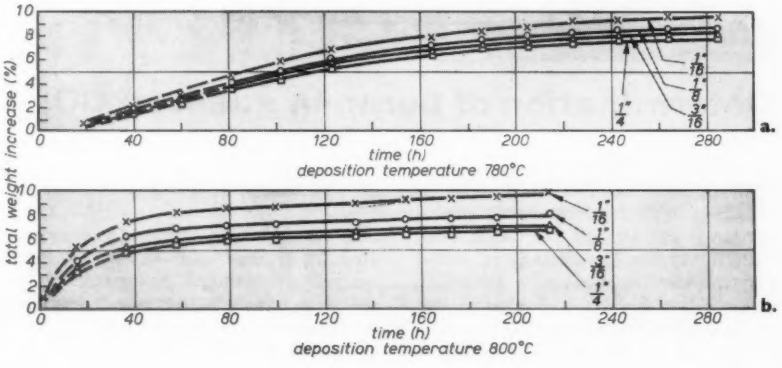
The behaviour of furfuryl alcohol resin on carbonizing allows the pitch used as a binder in the manufacture of carbon and graphite materials to be replaced with furfuryl alcohol. Unlike pitch this is smoothly converted to carbon without an intermediate liquid phase and is obtainable without objectionable impurities. Tubes made with coke and graphite powders bonded with the resin can be carbonized and heated to high temperatures. The permeability of these tubes is much lower than those obtained by conventional techniques for manufacturing graphite. Mr M. S. T. Price of Chemical Engineering Division, AERE Harwell, has independently used furfuryl alcohol resin as the sole binder. He has extruded bars 2¾ in. diameter which have been carbonized and subsequently graphitized successfully. The permeability of the product normal to the extrusion direction was 5×10^{-4} cm^2/s, about 50 times lower than a conventional low permeability graphite.

Gas impregnation

Previous work on the deposition of carbon from hydrocarbons on to graphite surfaces showed that the density of the deposits produced at surface temperatures of 2000°C – 2100°C approached that of graphite crystals (*2, 3*). The deposits are highly orientated with the basal plane normal to the surface (*3, 4*). In consequence of this, since graphite is highly anisotropic in thermal expansion (*5*), the deposits develop circumferential cracks internally and also separate from the substrate on cooling. It is therefore difficult to produce impermeable graphite articles by surface coatings of carbon deposited at these temperatures. Nevertheless, by working at 1400°C thin adherent impermeable coatings can be obtained.

A more satisfactory method would

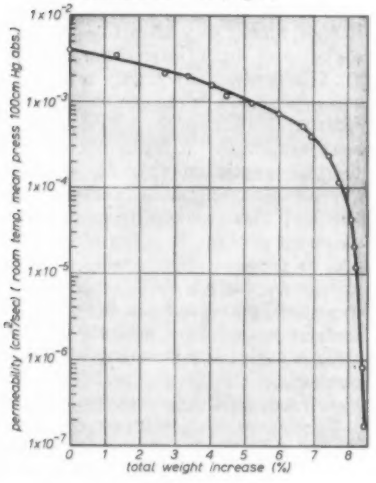
Deposition from nitrogen saturated with benzene at 0°C (Fig 3)



be one in which pyrolytic carbon was deposited within the pores of a graphite material. It occurred to us that by working at a temperature at which the reaction probability for the pyrolysis of the hydrocarbon gas was sufficiently low, so that the molecules could penetrate into the pores before carbon deposition occurred, this might be achieved. The work of Tesner (*6*) indicated that this should be possible. Thiele (*7*) and Wheeler (*8*), by considering porous catalysts, have established a theoretical background for such a process.

The breakdown of a hydrocarbon is a complex process, probably involving a considerable number of steps. Nevertheless, it has been found that a simple concept of reaction probability leads to the expected result: as the deposition temperature is lowered the deposit penetrates more deeply into the internal structure of the material. The transition from surface coating to deposition in depth can take place over a very limited temperature range. Thus we have found that, using a fine grained commercial graphite as starting material and depositing from a nitrogen-benzene vapour atmosphere, the transition from surface to internal deposit occurs in the range 750 to 800°C, depending on the partial pressure of the benzene vapour. By continuing the treatment until no further internal deposition occurs a material which is highly impermeable to gases is obtained.

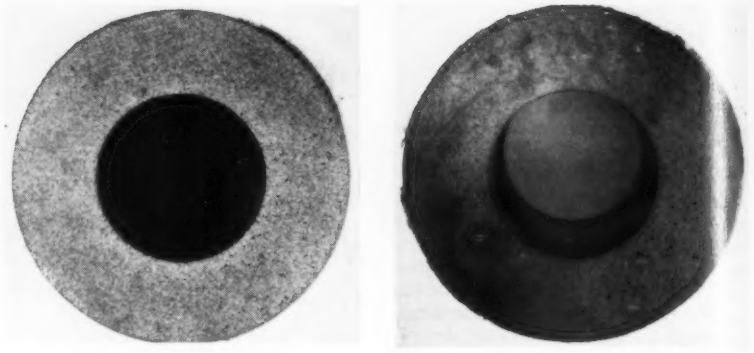
Permeability of a tube treated at 750°C in nitrogen saturated with benzene at 0°C (Fig 4)



The effect of temperature on penetration in depth is illustrated in figures 3a and b. These show the percentage weight increase of disks of differing thickness treated at temperatures of 780 and 800°C in an atmosphere of nitrogen saturated with benzene at 0°C. If there were complete penetration in depth the percentage weight increase for all the disks should be the same. The disks heated at 780°C took up approximately 7½ to 9 wt % of carbon, with no detectable dimensional change; the results for those treated at 800°C show a wider spread between the weight uptake on a percentage basis for the thin and thick disks, and in this case there was an average increase in the dimensions of the disks of 0·003 in. indicating formation of a surface coating.

Figure 4 is a typical plot of permeability versus percentage weight uptake. A tube treated at 750°C which gained 7·4% by weight and a final permeability of $1{\cdot}5 \times 10^{-9}$ cm²/s. (This corresponds to a leak rate to air in a vacuum system of 10^{-6} lusecs per cm² through a 1 cm thick wall.)

Figure 5 shows a piece of fine grain commercial graphite, a. after a gas impregnation treatment in a benzene containing atmosphere at 750°C, during which there was a 8·69% increase in weight without dimensional change, b. after a similar treatment at 900°C showing the silvery coating produced at the higher temperatures.



Samples of fine grain commercial graphite were given gas impregnation treatments, a. at left, at 750°C and b. at 900°C (Fig 5)

Combination processes

The two processes described above, which have been termed liquid and gas impregnation, may be combined by gas impregnation after one liquid impregnation or doing the liquid impregnation after a gas impregnation, to give maximum protection in depth.

Acknowledgments

This work was carried out at the Royal Aircraft Establishment, and has been partially sponsored by the UKAEA, to whom we are indebted for permission to publish this paper. The furfuryl alcohol process is being scaled up to pilot plant production at the Hawker Siddeley Nuclear Power Company Limited, under the technical advice of the Royal Aircraft Establishment.

We acknowledge with thanks the help of Mr G. Christie on the furfuryl alcohol impregnation work and we also wish to thank Mr R. A. U. Huddle for his interest and encouragement in this work.

References

1. These processes are the subject of 8 patent applications originating at RAE, filed in Britain and abroad and include BP App No 37106/57 (filed Nov 1957)
2. Pirani, M., and Fehse, W., *Zeit Elektrochem* 1923, *29*, p 168-174
3. Brown, A. R. G., and Watt, W., SCI Conference *Industrial Carbon and Graphite* London, 1957
4. Meyer, L., Picus, G. S., and Johnston, W. G., *NBS Circular* 1952 (519), Oct p 249-252
5. Nelson, J. B., and Riley, D. P., *Proc Phys Soc* 1945, *57* (6) p 477-485
6. Tesner, P. A., *Dok Akad Nauk SSSR* 1956, *110* (4) p 620-622
7. Thiele, R. W., *Ind & Eng Chem* 1939, *31*, p 916-920
8. Wheeler, A., *Advances in Catalysis* Academic Press Inc, NY, 1951, p 249-327

Nuclear Technology Processes

Determination of boron in gaseous CO_2

by Chemical Services Department, Windscale

THE CARBON DIOXIDE gas is passed through a gas absorption chamber until the air has been displaced. Sodium hydroxide solution is added and the carbon dioxide is absorbed. The solution is made just alkaline and evaporated to low volume. The acidity is adjusted and the boron is separated by distillation as methyl borate and collected in a sodium hydroxide glycerol mixture. The distillate is evaporated to dryness and the dry ignited residue of sodium hydroxide and sodium borate is heated with curcumin in the presence of oxalic and hydrochloric acids under controlled conditions. Rubro-curcumin is formed and the residue is dissolved in an aqueous solution of ethanol. Boron is determined absorptiometrically on a Spekker absorptiometer fitted with Ilford No 605 filters. The limit of detection is judged to be not greater than 0·05 ppm but it depends on the purity of the reagents.

This article is a condensed version of UKAEA report no IGO-AM/W-176, HMSO price 2s.

Activity measurements on flux-scanning wires

by W. ABSON and M. AWCOCK, *A.E.R.E., Harwell*

TWO IONIZATION CHAMBERS were designed for the measurement of activation in wires, to meet flux scanning requirements in graphite-moderated reactors with core sizes of 10 feet or more and in reactors of the heavy water type with cores about 2 feet in length. In both cases it was necessary to be able to measure flux densities over a range of about 100:1 at power levels ranging from full power to at least 10^{-2} of maximum power.

For the larger size cores adequate resolution is obtained with a detection system which measures the average flux density over a 10 cm distance. This can be achieved by measuring the gamma activity of an irradiated wire with an ion chamber having overall dimensions of about 10 cm. The activated wire (tungsten $T_{\frac{1}{2}} = 24$ hours) is passed through a central hole in the chamber in order to obtain good detection efficiency for the gamma radiation from the wire within the chamber, and to minimize variations in response due to lateral movement of the wire. The chamber may be placed in position over the channel to be measured and the chamber response measured as the irradiated wire is withdrawn through the chamber. Alternatively the irradiated wire may be withdrawn directly and wound onto a spool in a shielded container. The shielded spool may then be removed to a separate measuring position and the wire lowered vertically through the ionization chamber into a vertical mortuary hole. In each case it is necessary to provide some shielding between the chamber and the winding spool to reduce the ion chamber current due to gamma activity of the wire in the spool.

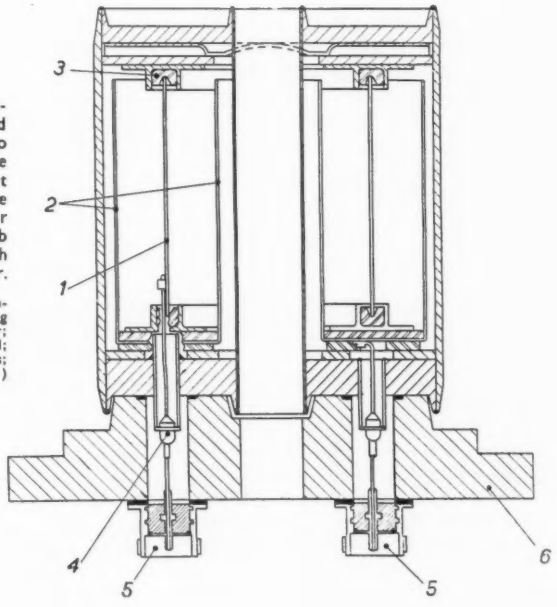
For reactors with smaller cores, e.g. DIDO, which has a fuel element approximately 60 cm long, the detection system is required to give a measurement of the average flux over a length of about $1\frac{1}{2}$ cm. Whilst this might be achieved with a gamma-sensitive detector similar to that mentioned above, but with all dimensions scaled down by a factor of about 6·5, it is more convenient to use a beta-sensitive chamber in order to improve the resolution. The chamber used is in the form of two parallel annular disks, about 10 cm dia, with a thin-walled tube through the centres of the disks down which the wire may be passed. A nickel wire may be used for high flux measurements (above about 10^{11} n/cm²/s) and 90%Mn/10%Ni alloy wire for lower flux levels. The induced activities in Mn and Ni have approximately the same half-life ($T_{\frac{1}{2}} \sim 2{\cdot}6$ hours). The activation cross-sections for pure Ni and the Mn-Ni alloy are in the ratio of 1:1000 approximately.

The gamma-sensitive ionization chamber (AERE Type 1544A) is shown in figure 1. The ion chamber is pumped through a copper tube brazed into the base-plate, filled with argon at 5 atmospheres absolute and sealed-off by crimping and soft-soldering the copper tube. The sensitive volume is approximately 650 cm³. The insulation resistance of the electrodes is of the order of 10^{13} ohms. To prevent moisture condensation and contamination of the external surfaces of the Kovar-glass seals, the cavities surrounding them are packed with silicone grease type MS4.

A concrete plinth has also been designed suitable for mounting the ionization chamber over a mortuary hole. The shielded wire-winding mechanism is fitted on top of the plinth and the wire may then be lowered through the chamber.

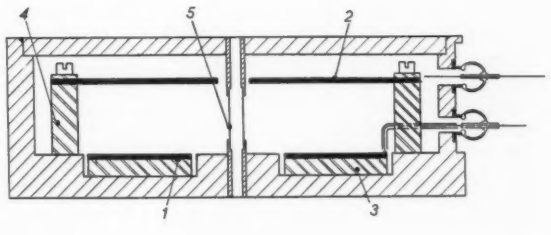
Tungsten has suitable nuclear characteristics (activation cross-section and half-life) for use in large reactors. The n, γ reaction with tungsten-186 (28·4% abundant) produces tungsten-187 which has a β, γ activity and a half-life of 24 hours.

A 7 × 0·006 tungsten wire has been used; irradiation for one hour in a thermal neutron flux of 10^{12} produces an activity of about 0·7 mc per cm length of the wire. The ionization current produced when a length of wire irradiated at this level is placed in the central hole is about 6×10^{-10} amp.



The gamma chamber consists of two coaxial mild steel cylinders welded to annular end plates. The inner cylinder is open at both ends so that the activated wire, together with a 1 in. dia plumb bob, can be passed through the centre of the chamber.

1. collector electrode (aluminium cylinder); 2. polarizing electrodes; 3. p.t.f.e. insulator; 4. Kovar glass-to-metal seal; 5. coaxial connector plugs; 6. steel base plate (Fig 1)



The beta chamber has a brass body; electrode leads are brought out through Kovar glass-to-metal seals

1. brass collector electrodes; 2. h.t. electrode; 3. p.t.f.e. insulator; 4. p.t.f.e. post; 5. 0·002 in. wall copper tube beta window (Fig 2)

This current applies to a measurement taken immediately after the 1 hour irradiation period, and a decay correction will be necessary for later times of measurement. Tungsten wire can be obtained in sufficiently pure form to give a decay constant characteristic of $^{187}W(T_{\frac{1}{2}} = 24$ h) over a period of several days, without interference from other induced activities due to impurities. For irradiation periods which are short compared with the half-life (e.g. up to 1 hour), the induced activity and the chamber current is proportional to flux times exposure time. The lower level of flux measurement is determined by the lower limit of measurement of ion chamber current, the upper limit by the saturation characteristics of the ion chamber.

Figure 2 shows a section of the beta-sensitive ion chamber designed for use with Ni and Mn-Ni wires of about 0·02 in. dia, for flux-scanning measurements in reactor cores of a few feet in length. The ion chamber has a sensitive volume of 210 cm³ and is filled with argon to a pressure of 77 cm Hg. It is pumped and filled through a copper tube which is brazed into the body, and sealed-off by crimping and soft-soldering.

For high-level flux measurements, a pure nickel wire of 0·018 in. dia gives a suitable level of activity for measurement in the ion chamber. The n, γ reaction with ^{64}Ni (1% abundant) produces ^{65}Ni which has a β, γ activity and a half-life of 2·56 hours. The ion chamber current produced by a Ni wire of 0·018 in. dia, following irradiation for 10 min. in a thermal neutron flux of about 10^{12} n/cm²/s, is 7×10^{-12} amps. This gives a good compromise between beta-response and total gamma activity and is a convenient size for handling. The attenuation effect of the 0·002 in. wall copper tube on the chamber current is about 30%.

The ion-chamber collection efficiency is greater than 99% for currents up to 10^{-8} amp with a polarizing voltage of 100 volts. Thus taking 10^{-8} amp as an upper limit of current and 10^{-12} amp as a lower limit, the range of flux measurement possible with 0·018 in. dia nickel wire and 10 min. irradiation period is $1{\cdot}4 \times 10^{11}$ to $1{\cdot}4 \times 10^{15}$ n/cm²/s.

The lower limit of measurement can be extended by the use of a 90% Mn/10%Ni alloy wire. The n, γ reaction with ^{55}Mn (100% abundant) produces ^{56}Mn, which has a β, γ activity with a half-life of 2·58 hours (a value conveniently near to that of ^{65}Ni).

With a 0·02 in. dia Mn-Ni wire, the ion chamber current immediately after a 10 min. irradiation period at 10^{12} n/cm²/s is about $7{\cdot}5 \times 10^{-9}$ amp. A lower limit of current measurement of 10^{-12} amp will then correspond to a flux of $1{\cdot}4 \times 10^{8}$ n/cm²/s.

This article is a condensed version of UKAEA report no AERE EL/M 100. HMSO price 2s 6d.

Nuclear Technology | Irradiation

Colorimetric analysis of radioactive solutions

by G. P. KITT and J. H. MOSS, *A.E.R.E., Harwell*

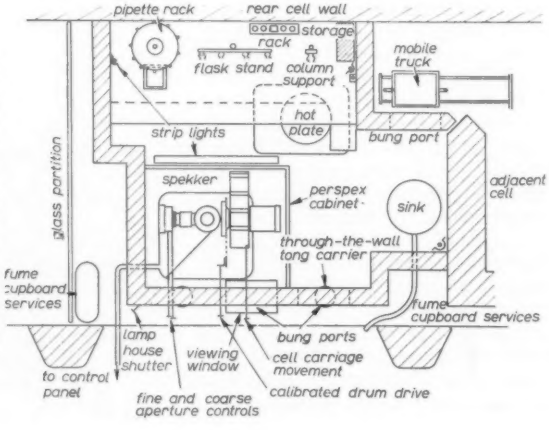
IN CONNEXION with the development of a process for the separation of Cs^{137} and Sr^{90} from mixed fission products, it was necessary to analyse solutions containing up to 100 millicuries of beta or gamma activity for trace quantities of aluminium, iron, tungsten and lead. Colorimetric methods were chosen since they are sufficiently sensitive to give the accuracy required when working with relatively small volumes of sample and usually only simple preparative procedures are involved when using specific colour-forming reagents.

A cell for carrying out the analyses was constructed using 2-in. lead walls in an adequately ventilated fume cupboard and was designed to contain a remotely operated Hilger Spekker Absorptiometer Type H560, with facilities for carrying out simple chemical procedures. The cell formed an annexe to a similar cell constructed with 4-in. lead walls from which the samples for analyses were obtained.

Very little alteration of the Spekker is required in order to operate it remotely. All the electrical controls are extended on leads, brought through a small hole in the cell wall and reassembled on a panel close to the galvanometer. Those controls such as the coarse and fine adjustment of the iris on the left-hand photoelectric cell, the opening of the lamphouse shutter and the movement of the carriage carrying the glass cells are simply extended through small holes in the lead wall. The lamphouse shutter uses a linked thrust rod joined with a short length of p.v.c. tubing in order to give the required movement.

For movement and setting of the calibrated drum, use is made of a bicycle chain wheel and sprocket with connecting chain, these being of the ⅜ in. narrow gauge variety so that the chain wheel attached to the calibrated drum does not foul the main body of the instrument. The sprocket wheel is driven through a bevel gear by a spindle entering through the front wall of the cell. Adequate sensitivity of movement of the calibrated drum is obtained with this control which has only a small backlash. It is thought that a simpler control using a Bowden wire cable attached to the drum would probably give similar sensitivity of movement.

This article is a condensed version of UKAEA report *A remotely operated Hilger Spekker absorptiometer for use with radioactive solutions*, no. AERE C/M 356. HMSO price 2s. 6d.



The Spekker is enclosed in a Perspex cabinet, standing outside the polythene tray fitting of the main cell floor in order to prevent undue contamination. Communication with the adjacent cell is provided by the mobile truck which can be moved by tongs provided in both cells. A large mirror, set at an angle above the top of the cell, covers the areas not seen through the window

Cross Section by GRACCHUS

WITH the many technical and economic hazards already associated with the building of nuclear power stations, it seems cruel that now a political hazard should be included. I refer of course to the 20·5 MW BWR which Mitchell Engineering of London and AMF Atomics of New York were to build at Santa Lucia, Cuba, for the National Bank. I understand from Mitchell's Gordon Jackson that after months of tricky technical and financial negotiations, the final contract was due to be signed on Jan 5. Speaking on Jan 7, Jackson told me that all communications with the island had been impossible for days and that he had no idea what the new regime would do about the contract.

I must say that I have the greatest sympathy for Mitchells in this affair. The loss, through no fault of their own, of the German RWE contract in 1957 was bad enough but the thought of the Cuban one falling through after the tremendous amount of work that has been put into it must be heartbreaking. There is no inherent reason of course why the new regime should not go ahead with the power station but it will probably be some time before a decision is available.

THE NATIONAL Reactor Testing Station of the USAEC is a well enough known name but few people in Britain can have any idea of its tremendous size or of its variety of reactors. Situated in the state of Idaho in a semi-desert region, the station covers an area about as big as the county of Surrey and further land acquisitions are planned for this year. When it was started in 1949 it was on the basis of ten reactors operating by 1964: actually there were 16 working and 7 more under construction by the end of 1958. The reactor facilities tend to be concentrated in groups but there's a a long way between groups. To get from the MTR for example to the aircraft propulsion reactors is a drive of about 25 miles: EBR-II is about the same but OMRE is comparatively near at about 8 miles!

In its 10-year history the NRTS has had two important firsts. In December 1957 EBR-I produced the first electricity in the world from nuclear power. It amounted to 100 kW and was used to provide light and power in the reactor building. On July 17, 1955, BORAX-III, supplying a turbogenerator, provided on a purely experimental basis, power and light for the neighbouring town of Arco (pop. 2000).

One of the Idaho site's most interesting facilities is the 'hot shop' at the Aircraft Nuclear Propulsion area. I suppose it could be described as a cell, but with dimensions 52 ft wide, 160 ft long and 60 ft high it seems some new word is needed. Perhaps 'cave' would be better. The walls are seven feet thick and windows six feet. It is used for dismantling and reassembling complete aircraft reactors under remote control.

SINCE all the excitement at Geneva over the various thermonuclear projects an uncanny hush has descended, although the subject is now completely declassified. It is almost as if all the scientists working on these projects, exhausted by their outpourings at Geneva, had decided to take extended holidays—or is it that they are all getting themselves ready for the Institution of Electrical Engineers' symposium on April 29–30 in London?

I see it is now exactly a year since we carried the first news about the Harwell ZETA machine: now there is a model of it in the Science Museum! This could be a bad sign and the fact that Peter Thonemann is shortly off for a year at Princeton adds force to the general impression I get that we can expect no major British contribution to the subject for some considerable time—not in fact until ZETA II is ready and so far there is no news of its construction even having been started.

HOUSE MAGAZINES often reflect the general spirit of a firm and I always find Richardson Westgarth's 'The Link' a lively and well-conceived publication. The current issue contains a hilarious contribution from Dr H. E. Davies, director of the company's Metallurgical Laboratories which ought to be made compulsory reading for authors. Entitled *Light Metallurgy* the article defines some of the most common scientific clichés into which even the most experienced author is apt to drop without warning. I quote a few examples.

'It has long been known that'—*I haven't bothered to look up the original references.*

'The W-Pb system was chosen as especially suitable to show the predicted behaviour'—*The fellow in the next lab had some already made up.*

'Three of the samples were chosen for detailed study'—*The results on the others didn't make sense and were ignored.*

'Given a homogenizing anneal'—*Oxidized.*

'Typical results are shown'—*The best results are shown.*

'Thanks are due to Joe Smith for assistance with the experiments and to John Brown for valuable discussions' *Smith did the work and Brown explained what it meant.*

It has so far not been possible to offer satisfactory explanations of this aspect of author behaviour but it is hoped that this work will stimulate further research in the field.

COMPARISON of various possible structural materials in cases where there is a possibility of choice is always rather difficult but I've just been studying a publication which should go far to make things easier. The idea is to take a specific merit index and then arrange the materials in descending order. The indices number about forty and cover parameters such as maximum strength with minimum cost, maximum bending stiffness with minimum weight, maximum heat transfer with minimum volume. On this basis some surprising things emerge. For instance on the merit of bending strength to cost balsa wood emerges far ahead of anything else while judged on bending stiffness to cost portland cement has it! It is also surprising to find that for conducting electricity at minimum weight beryllium is twice as good as copper.

At present the tables don't include many of the more exotic metals but beryllium and titanium appear as most useful materials for all sorts of applications. The firm that operates the service, Materials Data Ltd, tell me the data, which is kept under constant revision and review, is all entered on punched cards and reduced by an electronic computer.

On record

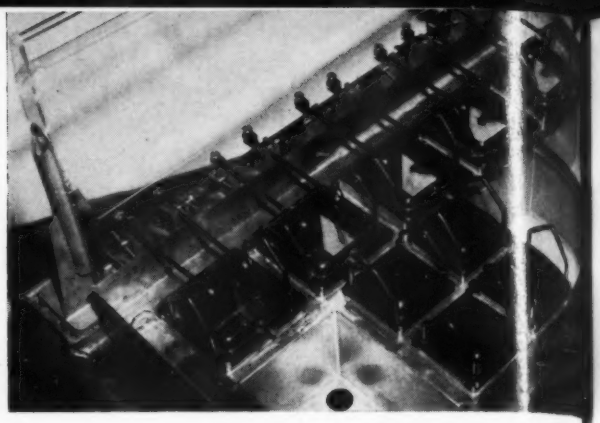
The arguments against nuclear war are now fairly well known.—'Observer' book reviewer

The new towns rival Britain's renowned nuclear energy enterprises as a factor in prestige abroad and attract swarms of visitors.—'Town and Country Planning'

The scientific interests affected if a nuclear power station were built at Dungeness—by far the most important shingle structure in the UK—would be very varied, including ornithology, entomology, botany, and above all physiography and ecology. — E. M. Nicholson, Director General of the Nature Conservancy

The fuel and the moderator

Research on both is aided by Spembly developments



After mechanical polishing under water in the bowls below an irradiated specimen is moved to the electropolishing station above where it is hung on one of the electrode arms over each tank

IN THE LAST YEAR or so the Kent firm of Spembly Ltd has carried out a steadily increasing volume of work for the Windscale, Harwell and Dounreay establishments of the Atomic Energy Authority, and *Progress* was recently invited to visit their works at Chatham. Just finished was a complete mounting, polishing, and demounting set up which will be used at the Dounreay irradiated fuel element laboratory to aid the metallagraphic examination of hot specimens. Designed and manufactured by the company under subcontract from Pye Ltd and the Industrial Group of the AEA, it is arranged to handle specimens in the form of 3 in. long × 0·7 in. dia. half cylinders with an 0·32 in. dia. groove down the flat face. All operations are carried out by Pye manipulators and the polishing is performed under water.

Mounting, polishing by remote control

In the first stage the specimen is mounted using pneumatic clamping devices, and the apparatus includes resin pouring arrangements and a hot-plate for resin curing. The specimen is mounted in plastic on an aluminium base to absorb the generated heat. 'As the heat output is of the order 25–50 W we had to do quite a number of heat transfer experiments and calculations before arriving at the best mounting arrangement,' said A. C. Thorne, head of the nuclear energy division.

A mock-up heating element is inserted into the 3000°C graphitizing furnace while a technician holds one of the water-cooled conical electrodes which support the element and carry the supply bus-bar connexions

After mounting, the specimen is moved to the mechanical polishing station where it is placed in turn on each of three 12 in. dia. turntables fitted in bowls. They are covered with different grades of waterproof abrasive paper and driven by one variable speed geared motor unit. A polishing head rotates the specimen eccentrically in the direction opposite to that of the turntables and allows the specimen face to take up the plane of the turntables. It can also index to each stage of polishing, i.e. to each of the three turntables. Since the polishing is carried out under 2 in. of water, a complete closed system of demineralized water circulation, draining and filtering, with a special reservoir which will not allow particles to collect, are provided. The water level is lowered when it is necessary to change the abrasive papers and the specimen is washed between each stage of polishing.

Microscope takes over

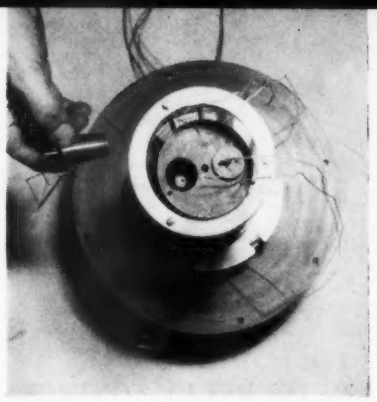
The next move is to the electropolishing station and the specimen is transferred in a water filled container to prevent oxidization and over-heating. The station consists mainly of a large stainless steel bench fitted with recessed compartments for tanks and washing baths, electrode arms, motors and stirrers, and an outside control cubicle. The five electropolishing polythene tanks measure about 6 × 6 × 6 in., each being mounted in the bench top under two electrode arms. Electropolishing is carried out by hanging the specimen from one and a cathode from the other and during the operation the electrolyte in the tank is continuously agitated by magnetic stirrers driven by fractional horse power motors fitted below the tanks. Further along the bench top are four more polythene tanks for etching and three washing baths which are used between different operations or before passing the specimen to the end of the cave for microscope examination.

The whole series of operations is controlled from a cubicle fitted outside the cave, which was also designed and manufactured by Spembly. Direct current is supplied to the electrode arms by flexible cable from adjacent junction boxes and is variable over the 0–20 amps 0–100 V range. The cubicle contains an a.c. voltage regulator 3 phase 50 c/s input, rectifier unit, fuses, switches and meters as well as the controls for the stirrer motors and the stop-start buttons for the water pump. A large perspex cover is fitted over the electropolishing tanks to prevent the manipulators accidentally touching the live electrodes, and this cover is electrically interlocked with the d.c. circuit of the control cubicle so that the electrode supply can only be made when the cover is down and in the safe operating position.

Other recent developments by the company include a 20 kVA graphitizing furnace designed in conjunction with Harwell for the heat treatment of graphite, and thermocouples and heaters for Wigner energy research at Windscale. The furnace can heat carbon billets $1\frac{1}{8}$ in. dia × 6 in. long up to

3000°C by means of a graphite tube heating element which is held by water cooled conical electrodes at each end; these carry the supply bus-bar connexions, and silica windows are fitted to allow temperature measurements to be made with a radiation pyrometer. So that the element can be replaced when necessary it is surrounded by an outer graphite tube, also water cooled at the ends, with a space between the two tubes. One electrode is connected to one end of the outer casing by means of stainless steel bellows which are insulated from the electrode, and take up to 0·3 in. expansion of the element. The space between the surrounding graphite tube and the outer casing is filled with pelleted lampblack insulation. Heating can be carried out under vacuum or in argon and a temperature of 2500°C can be reached in 30 minutes.

One of the pieces of apparatus developed for Wigner energy research is a stored energy calorimeter and furnace which compares the temperatures obtained from heating irradiated and non-irradiated graphite under identical conditions. The retaining copper plugs for the specimen holes are centrally drilled to take twin-bore silica (Vitreosil) tube which houses a pair of thermocouple wires whose junction rests on the graphite; another hole close to each specimen receives the junction of a differential thermocouple, the junction being lightly clamped at the bottom of the hole by means of a grub screw, and a further $\frac{1}{8}$ in. dia hole carries a single thermocouple which measures the body temperature directly. The heat former round the calorimeter is made up with silica rods held between stainless steel end rings.



Behaviour of irradiated and non-irradiated graphite specimens is compared by placing them on the ceramic supports in the calorimeter holes, fitting the copper plugs and energizing the surrounding heater winding

PROGRESS IN INDUSTRY

Storing and loading radioactive sources

New facility at Isotope Developments

AS MANUFACTURERS of industrial nucleonic equipment such as density and thickness gauges, level controls, package monitors, static eliminators, radiography sources, Isotope Developments Ltd handle a considerable amount of radioactive source material. The sources, in the form of capsules, pellets of foils come from the AEA's Amersham or Harwell establishments. Being all sealed or encapsulated there is no appreciable risk of a spread of loose activity but the sources have to be safely stored and then transferred to the holders when required and to accomplish this IDL have set up a new radioactive laboratory for source loading and a storage department. *Progress*, at the invitation of deputy chairman H. A. Luss, went to see something of these facilities at the Aldermaston factory where of course in addition, IDL's considerable range of electronic equipment is made.

Access to the store and laboratory is obtained only through the 'annexe' where overalls, overshoes, film badges or personal dosimeters are issued. The main feature of the store is a large barytes concrete block containing a number of 2 ft deep holes. This is used for gamma sources mainly in the form of radiographic capsules. Each hole is closed by a lead plug which carries below it a metal tube, closed at the bottom but cut away at the sides, in which the source, in an aluminium screw top container, is held at the bottom of the hole. When a capsule is required, the plug is raised by a miniature gantry hoist and the can removed by tongs to a trolley-mounted lead pot for transport to the gamma loading cell in the laboratory. The storage block is designed to hold up to 10 curies of Co-60 or 100 curies of Cs-137.

Beta sources, which are stored in a multi-compartment, lead-lined steel cabinet with $\frac{1}{2}$ in. steel doors to each compartment, are usually in the form of metal foils (Sr-90, Tl-204, Ru-106, Ce-106 etc) and before storing they are shielded with perspex, lead or by fitting into an IDL source unit before placing in the cabin.

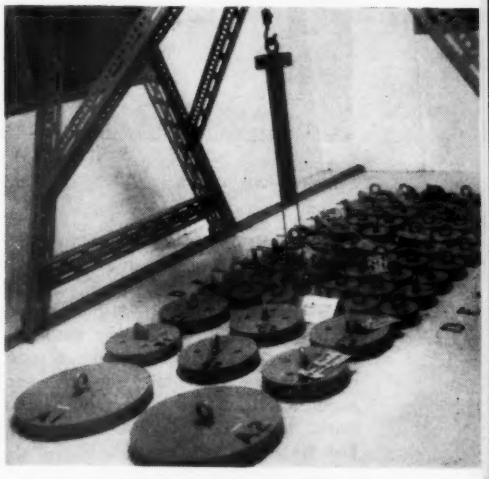
The laboratory, which connects directly with the store, contains a gamma loading cell, a perspex glove box for beta work and a small fume cupboard, used mostly for handling radium foils and some tracer experiments.

Strict housekeeping

The gamma cell is of concrete with a front wall of 4 in. chevron lead bricks incorporating an 8 in. lead glass window and sets of Harwell tongs. Holders and sources in the transport trolley are brought through a door which is interconnected to an IDL gammaswitch which gives a warning if it is opened while a source is exposed. In the cell, the aluminium can is opened and the source transferred to the holder.

As previously mentioned most of the work is with encapsulated sources but some work is done with 'open' material in the form of liquids or powders. To cope with a possible spill the flooring is in semi-tropical asphalt which has a non-absorbent surface. Wall and ceiling are lined with plaster board to give a ledge-free surface and painted with chlorinated rubber paint. Working surfaces are covered with smooth plastic material.

The firm maintain a comprehensive system of stock control, disks hung on a large hook board showing the location of all sources on the premises. When a source is despatched to a customer the holder is stamped with a serial number, the nature and activity of the isotope and the date of installation. This information also goes to HM Factory Inspectorate.



Gamma sources are stored in a barytes concrete block and removed when required by a miniature goliath crane

Radiological safety content at the factory is in the hands of the firm's health officer Miss P. M. Bryant, who is directly responsible to the joint managing director, Mr G. F. Thick.

New Product Survey

PLANT · EQUIPMENT · INSTRUMENTS · MATERIALS

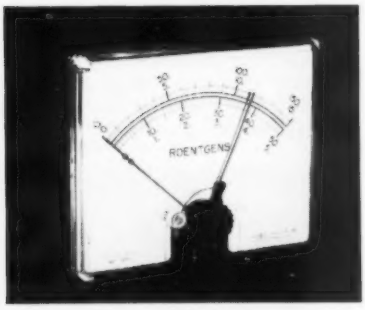
METER-RELAY CONTROLS

small and compact

A new minified control, announced by Assembly Products Inc, is believed to be the smallest self-contained instrument ever built in production quantities round locking contact meter relays and occupies the same panel space as a standard 4½-in. indicating meter.

Like most meter relay controls, the new unit provides continual signal indication and when preset limits are reached, it triggers control action by appropriate equipment. Either high or low signal limits may be set by adjusting fixed pointers. Signals from virtually any variable may be controlled, usually without amplification.

For manual reset operation, the control may be used with 4½-in. API meter relays of any sensitivity, beginning with



All components—including power supply—are housed in the 2⅞ in. dia. body

ranges of 0 to 5 microamperes and 0 to 5 millivolts. In such controls, the load relay is rated at 2 amperes. One manual reset circuit is available with a ruggedized meter relay. For simple automatic operation, maximum sensitivity of meter relays is approximately 200 microamperes. Rating of the load relay in automatic circuits is 1 ampere.

Tick **No 185** on reply card

TUBE WELD PREPARATION

portable machining rig

Reduced cost and greater output in the preparation of tubes for butt welding have been achieved at the Glasgow works of John Brown Land Boilers by the use of simple portable rigs which are easily moved about the works thus allowing machining to take place at any convenient location and eliminating the need for expensive horizontal boring and

The machine is used for preparing butt welds in a superheater unit at John Brown Land Boilers

facing machines which would require the work to be brought to them.

Each rig consists of a Consolidated Pneumatic type 350-R-100 heavy-duty power vane drill mounted in line with two ball races and a vice on a common baseplate. The drill is fitted with a No 5 morse taper spindle which is held rigidly by the ball races spaced 5½ in. apart. A specially designed cutter head carrying two Cleveland twist drill cutters of 10% cobalt steel is mounted on the spindle, the head carrying recesses for cutting teeth suitable for dealing with tubes in the size range of 1½ in. o.d. to 6 in. o.d. and thicknesses of from 10 gauge up to ½ in.

A particular feature of the assembly is that whilst the rig allows of working to within limits of ·005 in. only semi-skilled labour is required for its operation and head change is accomplished in a matter of seconds by the operators.

Tick **No 186** on reply card

TEMPERATURE TRANSMITTER

now uses helium

Latest version of the Sunvic pneumatic temperature transmitter uses high purity helium as filling gas in the thermal system. Helium has been selected for several reasons. Firstly, it is chemically inert and damage to the bulb can have no adverse effect on a process, even in the case of explosives or food. Secondly, the thermal conductivity of helium is good, ensuring rapid response of the instrument to changes in temperature. Moreover, use of helium makes it possible to test the complete thermal system in a mass spectrometer, so that even the most minute leak can be unerringly detected. This, combined with the fact that the thermal system is filled at comparatively low pressure, so that volumetric changes of the bulb at high temperatures are reduced to a minimum, ensures excellent long-term stability.

As with other Sunvic temperature transmitters, in the new Model 33H the thermal element can be changed without use of tools, so that replacement of a damaged element, or changing the range, can be performed simply and *in situ*. Construction is extremely simple; no beams, pivots, links or bearings are used, so that wear and friction are eliminated and dead-spot and hysteresis are at a remarkably low level.

Since the filling medium is high purity helium very low temperatures indeed can be measured, and the thermometer is sensitive to changes in measured temperature of the order of 0·01% of range.

Tick **No 187** on reply card

NEW P/M TUBES

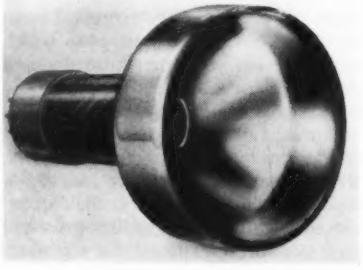
many applications foreseen

A range of eight photomultiplier tubes for scintillation counting and industrial applications is being introduced by Mullard. It comprises one 15-stage, five 11-stage and two 10-stage tubes. All have maximum spectral response in the blue/violet region (4000 to 4200A) and, in addition, two are fitted with quartz windows to allow adequate response to ultra-violet radiation. The tubes are designed for end-on viewing and have caesium-antimony photocathodes, ranging from 20 to 111mm in useful diameter, with optically flat and parallel surfaces.

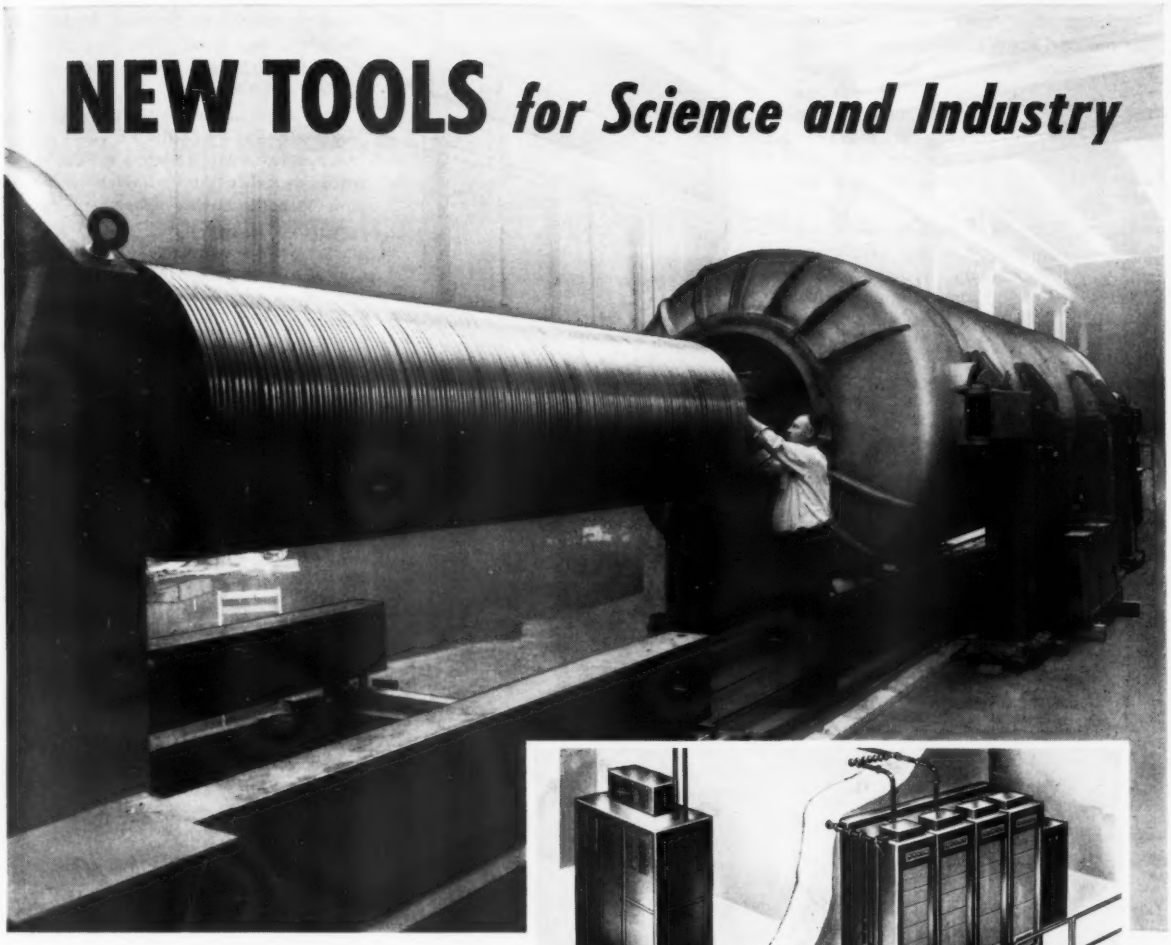
The introduction of these tubes follows an intensive development programme. In particular, the construction, arrangement and mounting of the secondary cathodes has been the subject of exhaustive studies aimed at producing a multiplier system giving a high current gain, minute dark current and minimum variation of electron transit time.

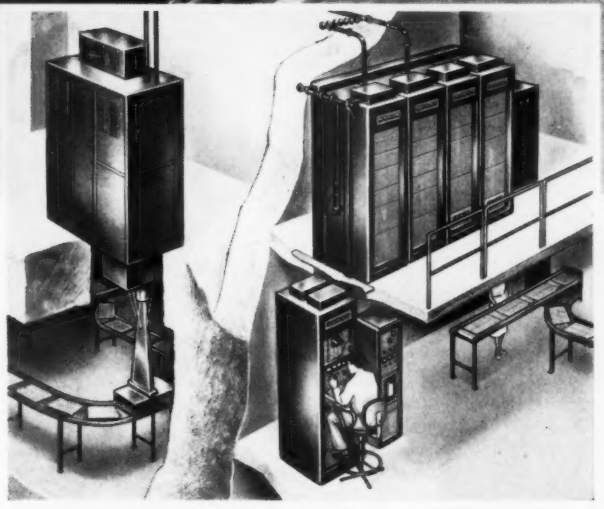
High current gains have been achieved by the use of precision-mounted solid cathodes machined to carefully controlled shapes and dimensions from specially treated silver magnesium. Solid cathodes have been chosen since they are capable of giving a higher gain per stage than either the sieve or venetian-

This 11-stage photomultiplier tube, type 54AVP, has a photocathode of 111 mm useful diameter



NEW TOOLS *for Science and Industry*





for Science . . .

The first 10-Mev Tandem Van de Graaff makes possible the exploration of binding energies in heavy elements, for basic atomic-reactor design. Now accurate data will be available to nuclear physicists, in the energy range above 9 Mev.

for Industry . . .

The first full-scale commercial application of electron-beam processing is providing an improved product and new operating efficiency. Ethicon, Inc. sterilizes surgical sutures with ionizing electrons from their HIGH VOLTAGE 7-Mev microwave linear accelerator.

More "Firsts" in high-powered particle accelerators are in advanced design stages at HIGH VOLTAGE ENGINEERING to meet the increasing demand for *ELECTRONIZED®* products. Nearly 200 accelerators designed and built by HIGH VOLTAGE are now in service, and a radiation facility is available for your use at our plant. Bring your product or problem to our technical sales department.

HIGH VOLTAGE ENGINEERING
CORPORATION
BURLINGTON MASSACHUSETTS

Tick **No 56** on reply card for further details

blind type of electrode; and, in addition, the material itself has excellent secondary emission properties, which remain stable over long periods of time. Another factor contributing to the high gain is the efficiency of the input electron-optical system, which is so designed that over 90% of the photo-electrons reach the first secondary cathode.

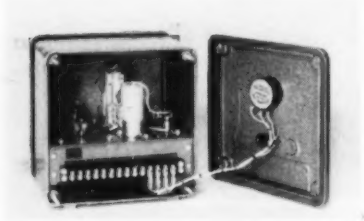
Besides their uses in scintillation counting these new tubes will also have applications in photometry, pyrometry, and many kinds of industrial counting, control and measurement processes.

Tick **No 188** on reply card

PROCESS TIMERS

accuracy with economy

A new series of economically priced electronic process timers has recently been added to the wide range already produced by Lancashire Dynamo Electronic Products. The new units, known as Series PCT 1 are available in six basic forms depending upon the required time range and can be connected together to provide multi-stage timing control for complete processes.



The electronics are housed in a substantial light alloy casing for wall- or base-mounting

The six basic models are designed to provide time ranges of (a) 0·1 to 1·5 seconds; (b) 0·3 to 5 seconds; (c) 1 to 15 seconds; (d) 3 to 50 seconds; (e) 10 to 150 seconds and (f) 30 to 500 seconds. Each main time range is sub-divided into 'Long' and 'Short' ranges selected by a switch and a continuously variable control is provided for accurate setting of the required time interval. The units have a repeat accuracy of ± 1% on a stable supply and variations in supply voltage of −15% to +10% will not cause more than +5% change in the set time interval.

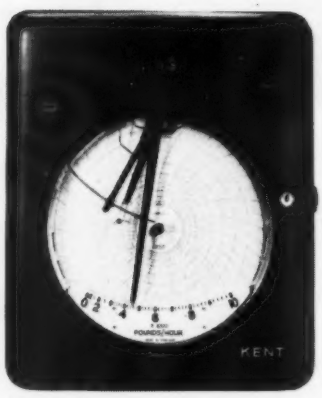
Tick **No 189** on reply card

PRESSURE RECORDERS

new range from Kents

George Kent Ltd announce the addition to their *Commander* range of the new Kent-Barton mercuryless diaphragm instrument for the measurement of differential pressures in six maximum ranges and up to 2500 psi working pressure.

These instruments, available intrinsically as circular-chart recorders, sector-scale indicators and circular-scale indicators, incorporate the *Barton* patented rupture-proof differential unit, which—although employing sensitive bellows for its actuating element—may be subjected to pressure differences equivalent to the pressure rating of the instrument without damage. Full line pressure can be applied across the bellows unit in either direction without damage—irrespective of the differential-pressure range of the instrument—owing to the valve in each bellows.



The Kent-Barton instrument shown is a flow recorder-controller with crescent-scale indication

The torque-tube drive for conveying bellows movement to the instrument-index mechanism is leakage-free and requires no periodic lubrication, being virtually frictionless for the life of the instrument. Only the bellows exteriors are exposed to the metered fluid, and the unit is therefore completely self draining or venting; is without pockets to trap condensates and sediment formations; has no small tubes or other restrictions to interfere with its function.

Tick **No 190** on reply card

PROCESS COMPUTER

for fully automatic control

The first transistor electronic digital computer designed to provide fully automatic control of many industrial processes is being developed by Ferranti. It is about the size of two small office filing cabinets and first production models are expected available in 1960.

Expected in full production next year, the computer uses transistors, core stores and printed circuits

At present in the prototype stage it is technically known as the PCTC (Process Control Transistor Computer). The transistor logical circuits in the computer have been thoroughly tested and an experimental model has controlled a machine which simulates a plant process for more than 2000 hours operation without component failure. Additional vibration and temperature tests have also been carried out to simulate the most rigorous conditions the computer is likely to meet in industrial use.

The computer is being specifically developed as the centre unit in control systems for a variety of industrial processes, such as may be found in the power, chemical, oil, gas and steel industries. Babcock & Wilcox Limited and their associates Bailey Meters & Controls Ltd. are currently investigating with Ferranti Ltd the feasibility of using this new computer for the control of boilers during start-up and shut-down.

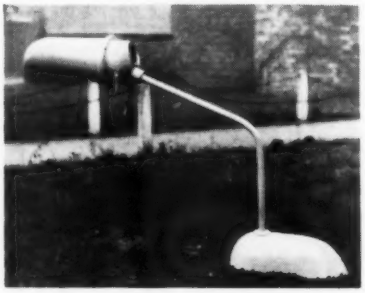
The price of the new computer will probably be in the range of £20,000-£50,000, depending on the size of the installation.

Tick **No 191** on reply card

GROUND MONITOR

For central recording

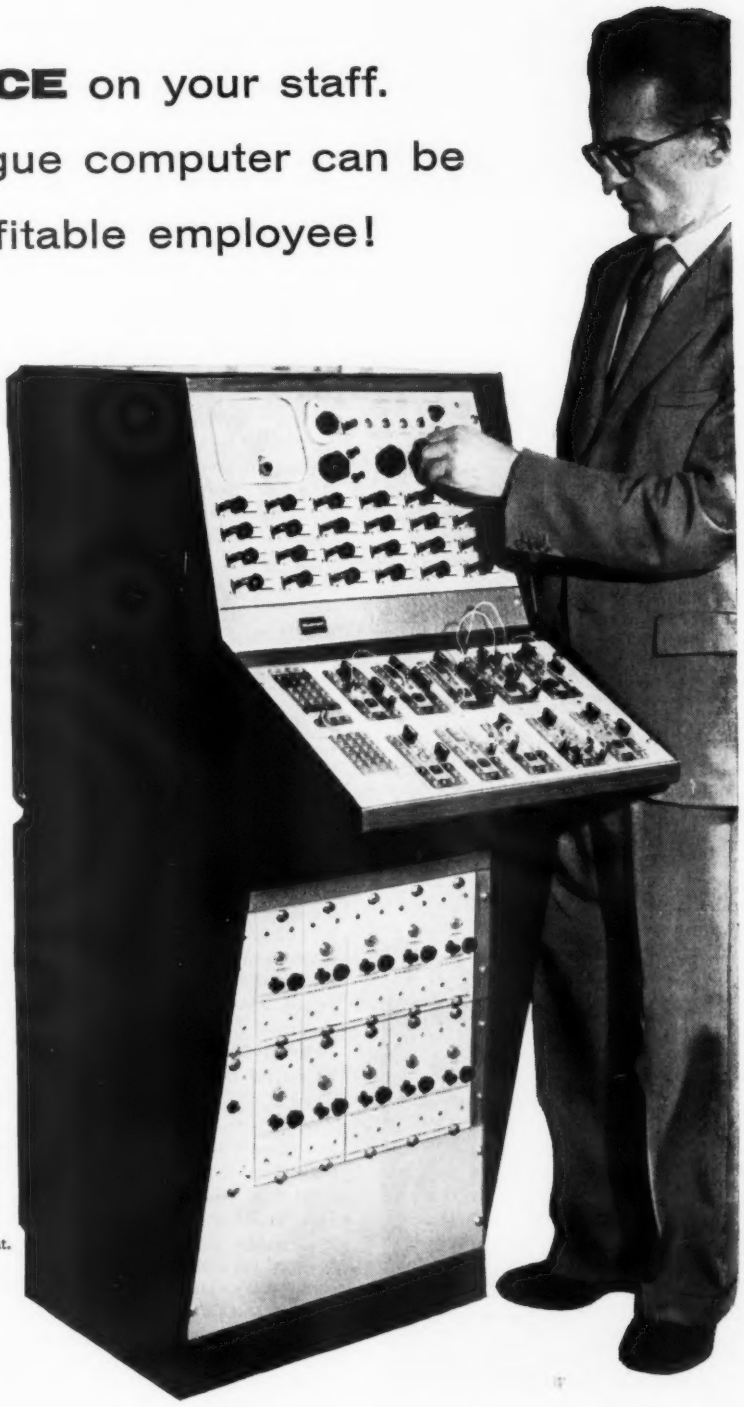
As mentioned briefly in last month's *Products*, Elliott Bros are producing a transistorized version of their ground contamination monitor. The detector unit comprises an aluminium casting which forms a protective cowl for a geiger tube and is so shaped that a known ground area is monitored. The casting houses also the transistorized amplifier, local ratemeter and a 2½ in. moving coil instrument giving visible indication of local count rate. The head is supported by a rigid tubular member from a heavy cast base which can be bolted to any suitable foundation. The construction of the equipment is such that it is completely



Units can be sited up to 2000 metres from the recording centre. The casing houses a local ratemeter

Put **MINISPACE** on your staff.

A Solartron analogue computer can be your most profitable employee!



The analogue computer is the supreme design tool for all dynamic problems. It rapidly repays its cost by savings in engineering development time. Proven in the aircraft industry and now developed by Solartron to the highest orders of accuracy, flexibility and reliability, you too can prove that *it is much cheaper to simulate your mistakes than to make them!*

Contrary to general belief, a computer need not be expensive or difficult to use. Solartron MINISPACE costs only £1,600 — a fraction of the amount often lost in making "trial and error" models — and does not require a specialist operator.

MINISPACE is just one example of the SPACE* construction principle, which allows a computer of any size to be assembled if necessary in phase with your budgetary programme. For more complex problems, SPACE '48' is a typical larger Solartron computer with 48 or more operational amplifiers, many non-linear units, removable problem board and digital voltmeter programming. There is infinite scope for expansion or tailoring to individual requirements.

Solartron advisory engineers will be happy to discuss your problems. Analogue computer application report and literature are available on request.

* SPACE: Solartron Precision Analogue Computing Equipment.

SOLARTRON

THE SOLARTRON ELECTRONIC GROUP LIMITED

Thames Ditton, Surrey. Tel: EMBerbrook 5522 Cables: Solartron, Thames Ditton

weatherproof and will operate continuously without maintenance.

The detecting element is either an all-metal gamma counter or a thin walled beta plus gamma counter. The pulses from the counter are amplified by transistor circuits and transmitted by coaxial cable to the central recording station. Power supply to each field station is 12 V d.c. at 200 mW and is carried by the common signal cable; this supply is provided from the central recorder. E.h.t. supply for each counter is generated in the individual heads so that failure of one supply does not render all monitors inoperative.

The multipoint recorder is of the Bristol Dynamaster type and a record of up to 12 field stations is displayed in multi-colour dot form on an 11 in. strip chart. Each remote detector is scanned in turn by the switch mechanism at an interval of 30 or 60 sec per unit.

The recorder is provided with its own transistorized ratemeter which is connected to the balancing amplifier and, in turn, to each signal input. Alarm contacts may be provided to give warning of high or low level signals and the settings are adjustable over 100% of the recorder range.

Tick **No 192** on reply card

CONTROLLER-RECORDER

simplicity with versatility

A new high-speed continuous balance null-type electronic potentiometer has recently been announced from Electroflo Meters. Known as the Series 197, the potentiometer is available as a single point recorder; a recorder with multiple alarm switching; a controller-recorder with two-step or proportional action and as a recorder-converter with pneumatic transmission signal of 3–15 psi. It is believed to be the simplest mechanism yet achieved in industrial potentiometer design, for the total motion is exercised through a single shaft which is mounted in ball races and the recording pen and indicating pointer as well as the control and multiple alarm switching, proportional sender, pneumatic converter and coding number are directly and positively related. Both the desired value indicator and the measured value pointer are readily observed from a distance.

Electroflo 197 registers low-potential electrical signals from thermocouples, flowmeters, strain-gauges, shaft position indicators

By incorporation of a scanner for process variables, the potentiometer may be used to generate a signal operating a print-out device. Another model (the Series 197-7) offers 24 push-button selector switches from 24 different temperature measuring points—the temperature showing up immediately on the scale at the top of the instrument.

Tick **No 193** on reply card

IN BRIEF

Silicon rectifiers Following licensing agreement between the Plessey Co and General Instruments Corporation, a new range of *Simet* silicon rectifiers is announced. Known as 'G' series, they're medium power and cover range 100–1000 peak inverse volts, 400–750 mA (25°C) and up to 250 mA at 150°C.

Tick **No 194** on reply card

Autoscaler Tracerlab's new model SC-51A is designed for geiger and scintillation counting and is adaptable to proportional counting by using an external amplifier. Advantages claimed: wide range of preset count, option to use binary scale over a decade scale which extends count capacity to 65,536 events with 12 preset counts.

Tick **No 195** on reply card

PM motors R. B. Pullin & Co Ltd have brought out a new international size 08 d.c. model—the 08PM. It's available for 6, 12, 18 volts and can provide up to 4 W output. There's also the new PM1C —a modified version of Pullin's well-known PM1 but with improved climatic endurance and longer life.

Tick **No 196** on reply card

Transistor testing Known as the Transistor Curve Tracer Type 1006, new Winston Electronics instrument measures and records characteristics of low power transistors—both p-n-p and n-p-n. Complete plot takes one minute.

Tick **No 197** on reply card

Relays Up to ten contact actions may be fitted on Siemans Edison Swan's new comb relay. Developed from the standard Post Office 3000-type relay it replaces the spring-set lifting pins by a lifting comb of synthetic resin-bonded paper which bears directly on the axial of the armature.

Tick **No 198** on reply card

Thermistors For temperature measurement and control of thermal drift in electrical circuits, The Plessey Co Ltd have announced a new range of thermistors. Made in four different mixtures of metallic oxides, they're available as disks, rods, bars, washers or beads.

Tick **No 199** on reply card

Spectrophotometer Unicam Ltd have replaced the natural quartz prism in their model SP500 with one of high purity fused silica. Important performance improvements are claimed.

Tick **No 200** on reply card

Fume hood Air Control Installations have announced an individual fume extractor to fit pot-type melting furnaces of the kind used by the non-ferrous metal industry. It's available for pots of 10 in. to 23 in. dia.

Tick **No 201** on reply card

Recorders Metrix Instruments Ltd announce new range of *Metrawatt* recording ammeters and voltmeters. Scale calibrations available: 250 microamp to 25 amp, 60 millivolt to 600 volt F.S.D. Centre or end zeros, a.c. or d.c. Various chart speeds—clockwork or electric drive.

Tick **No 202** on reply card

Temperature controller British Rototherm have added model 1036 to their range. It incorporates a mercury-in-steel actuated 4 in. dial thermometer. Feature of control is use of new mercury relay switch.

Tick **No 203** on reply card

Butterfly valves Cockburns Ltd have obtained licence from US for manufacture of W. S. Rockwell Co's 'wafer' valves. Suitable for gases, liquids and semi-solids they're made in sizes 4 in. to 36 in.

Tick **No 204** on reply card

Level control Fielden Electronic's *Tektor* capacitance level switch is now available in transistorized version (Type TT5). Battery or mains operation available.

Tick **No 205** on reply card

Limit switches New plug-in unit introduced by Square D Ltd. Known as Class 9007 Type AW-16, replacement involves only loosening two self-retaining screws.

Tick **No 206** on reply card

PTFE bearings *Polyslip* bearings by Bound Brook Bearings Ltd, consist of a porous bronze matrix impregnated with PTFE. The matrix carries the load and dissipates the heat, while the PTFE acts as lubricant.

Tick **No 207** on reply card

Fire extinguisher Nu-Swift's latest—model 1510—is a CO_2 model for liquid and electrical fires. It has a range of 15 ft and its fire fighting capacity is reported double that of the model 1210.

Tick **No 180** on reply card

Ceramic to metal seals Ferranti seals using aluminium ceramic with a low capture cross-section are reported compatible with liquid alkali metals, magnesium alloys, graphite etc.

Tick **No 181** on reply card

Tachometer for 1,800,000 rpm The Dawe type 715 transistor frequency meter has been introduced for measuring frequencies up to 30,000 c/s.

Tick **No 182** on reply card

INDUSTRIAL NEWSDESK

1154 MW more in 1958

During 1958 the Central Electricity Generating Board installed new generating plant giving an additional output capacity of 1,154,000 kW. Giving this figure the Board says that though it is smaller compared with previous years it conforms with the programme planned five years ago which took into account plant outstanding from earlier years and also the decision of the Government in 1953 to give priority to export orders for power station plant. Altogether 19 turbo-generators, with an aggregate installed capacity of 1,230,000 kW, and 17 boilers, with an aggregate evaporative capacity of 9,100,000 lb. of steam per hour, were installed in 16 power stations, belonging to the Generating Board in England and Wales, two of which were new stations.

Four of the 17 new boilers, having an aggregate capacity of 2,190,000 lb. of steam per hour, were oil fired. At seven existing stations a further 28 boilers, with an aggregate evaporative capacity of 11,200,000 lb. of steam per hour, were converted from coal to oil firing.

Vacuum heating firms team up

The General Electric Co Ltd announces that an agreement has been reached with Vacuum Industrial Applications Ltd of Wishaw, Scotland, which combines the resources of the two companies for the development of vacuum heating techniques and the design and manufacture of complete vacuum furnace installations. Both companies have considerable experience in this field, and Vacuum Industrial have specialized in industrial vacuum equipment including pumps, gauges, valves and pipelines, and themselves designed vacuum furnaces using induction heating units, including dual-purpose equipments with alternative resistance heating units.

More UK electronics for Canada?

More sales of British nucleonic instruments in Canada should result from a new move by EMI and Cossor. The directors of the two companies announce that they have decided on a policy of cooperation in the development of the Canadian market. This development will be based on Cossor's existing subsidiary, Cossor (Canada) Ltd, to which further capital will be subscribed by EMI. The effect will be to give EMI a controlling interest in the Canadian company, the name of which will be changed to EMI-Cossor Electronics Ltd. Cossor (Canada) Ltd has ten years' experience in communications instrumentation, using both the results of its own research and development and help from A. C. Cossor. To these will now be added the resources at the disposal of EMI, and a considerable range of electronic equipment including computers (both digital and analogue), data-logging equipment and nucleonic instruments. Henry Chisholm, joint managing director of A. C. Cossor Ltd, will continue as chairman of the Canadian company, and Clifford Metcalfe, a managing director of EMI, and managing director of EMI Electronics Ltd, will become president.

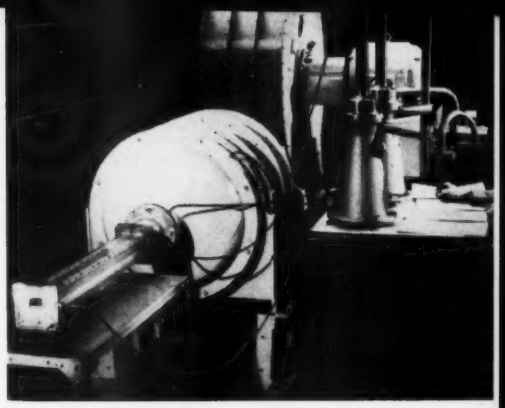
US General Nuclear taken over

The US Combustion Engineering Inc is to buy up General Nuclear Engineering Corporation of Dunedin, Florida, and run it as a subsidiary. Announcing this recently Combustion's chairman, Joseph Santry, said that Dr Walter Zinn, President of General Nuclear, will be in charge of all Combustion's nuclear power activities. Both concerns have considerable experience in atomic energy developments and Dr Zinn was director of the Argonne National Laboratory from 1946 to 1956.

NEW PHOTOMULTIPLIER ADVISER Peter Holton has moved from the photomultiplier production group at EMI to head the applications advisory team at 20th Century Electronics Ltd. He spent eight years at Harwell working on photomultiplier scintillation problems before leaving in 1955 to take charge of testing and application at EMI's

Sunvics give instrument talks

A one-day symposium on 'Instrumentation in the Process Industries' recently organized by Sunvic Controls Ltd, drew more than fifty directors and technical/commercial executives from other companies in the AEI group as well as from chemical and petroleum companies and electricity authorities. Chairman of the symposium was N. R. Davis, managing director of Sunvic Controls. Five papers were delivered by Sunvic executives. They covered techniques and applications of automatic control and instrumentation as at present applied to processes involving continuous flow production especially oil, chemicals and nuclear power and also surveyed future development and trends. Considerable emphasis was placed on data processing and automatic computation particularly in relation to possible applications in fully automatic plant control.



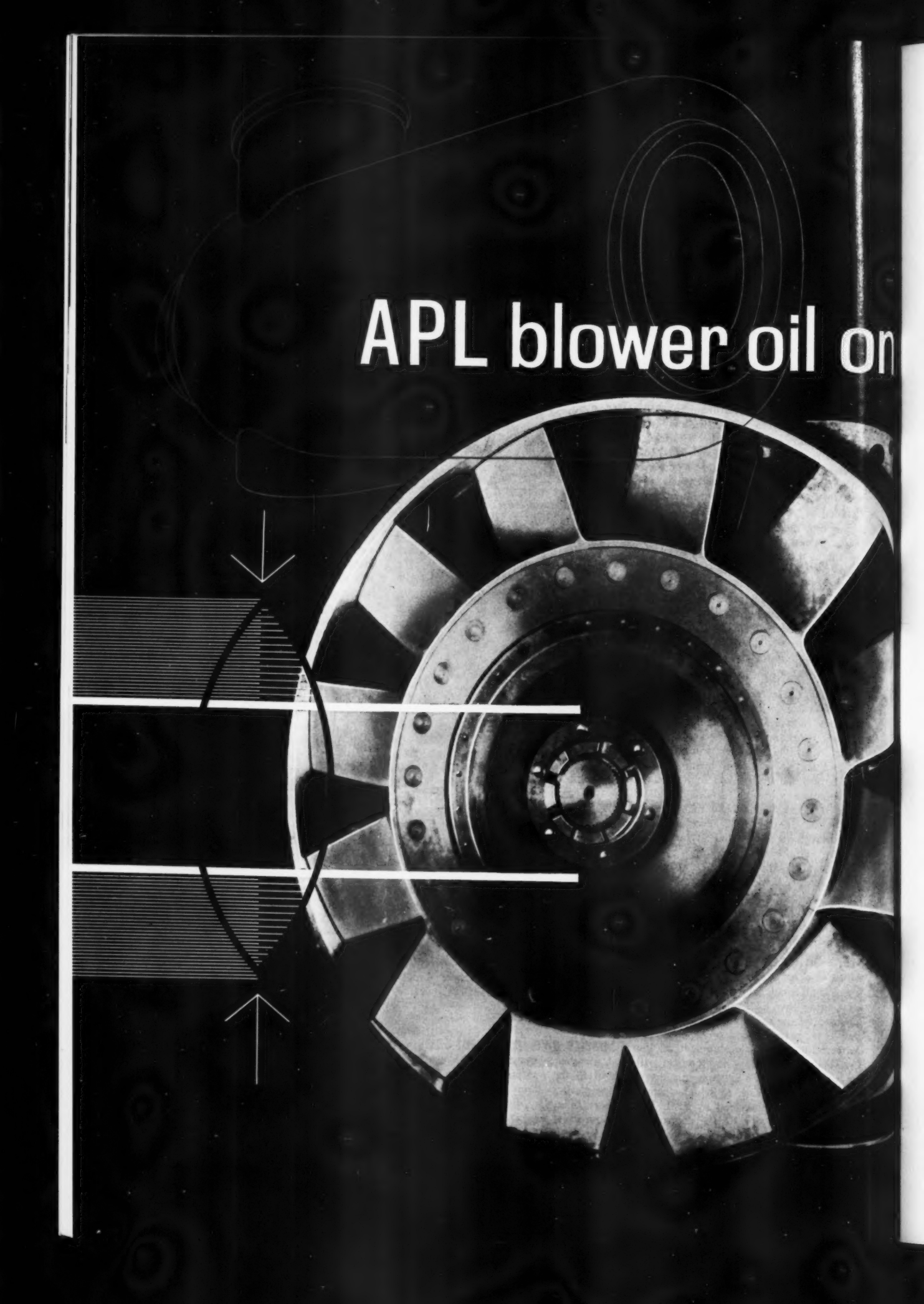
DESIGNING HINKLEY ELEMENTS This specially-designed air-pressure test rig is used by the English Electric Co to measure pressure drops across helical finned surfaces of the type adopted by the group for the 500 MW Hinkley Point station

Helium cheaper as liquid

The US National Bureau of Standards has made a study on the feasibility of transporting helium over long distances in liquid form which reveals that large-scale liquefaction plants and liquid distribution systems compare favourably with compressed gas systems; these use extremely heavy, high-pressure cylinder tank cars having a limited gas capacity, so that transportation costs are an appreciable percentage of the total.

The new process recommends the use of nitrogen or air rather than hydrogen as liquid pre-coolants, and the operation suggested is a simple Claude-type cycle which consists of one expansion engine operating at a temperature below that of a liquid nitrogen pre-coolant bath. A modification, made possible by a 155-atmosphere pressure differential, employs a second expansion engine in the helium-feed gas stream for the conservation of the liquid nitrogen refrigerant. The pressure of the helium feed from the production plant is 170 atmospheres while the operating pressure of the liquefier is only 15 atmospheres. The helium is transferred in pipe lines insulated and shielded with liquid nitrogen or liquid air from the liquefier to transportable containers, which would be of a conventional liquid-

[*continued on p* 102


APL blower oil on

sentry-go at Bradwell...

The crucial points of the high pressure CO_2 coolant circuit at Bradwell will be the blower shaft seals. Every minute of every working day Shell APL blower oil will guard these escape points—being continually pumped into the seals and bearings, led away, purified and recirculated.

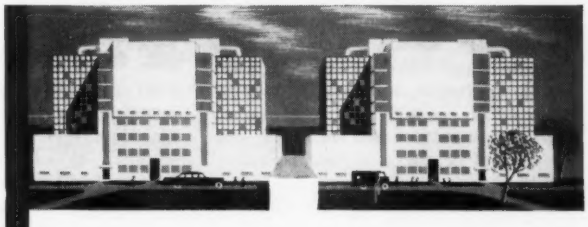
This very remarkable oil presents a two-way seal. Outwards, there is a minimum CO_2 loss as the oil has the lowest possible gas solubility. Inwards, in spite of the heat of the gas, oil vapour contamination is negligible thanks to the extremely low vapour pressure of the oil.

The research that went into APL blower oil is characteristic of the way Shell set about doing things. It was conducted at Shell's Research Centre at Thornton in close collaboration with the U.K. A.E.A. and the blower manufacturers. In the course of much fundamental research, a wide range of oils was subjected to vapour pressure and gas solubility tests in the laboratory. Selected oils from this range were used in the bearings and seals of a blower rig. In 1956, after four years of research, the finished product joined the Shell Atomic Power Lubricants range—marketed under the name of Shell APL 729. This oil has been in use at Calder Hall since the autumn of 1956.

The moral of the story is that Shell research is supremely applicational. The Centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organisation have any major lubrication problem it pays to get in touch with your local distributor of Shell Industrial Lubricants.

The Research Story

Though the sealing action demanded of Shell blower oil is common in other industrial equipment such as hydrogen-cooled alternators, there were quite a few additional problems. It was necessary for the oil to have long life, low vapour pressure, low gas solubility, good thermal stability and high film strength —to be able to withstand high temperatures and to be resistant to all kinds of corrosive influences, including carbonic acid. The crux of the research was to combine all the above requirements into one oil, in order to minimise back diffusion of molecules which would contaminate the reactor.



BRADWELL NUCLEAR POWER STATION. AN ARTIST'S IMPRESSION

SHELL

ATOMIC POWER LUBRICANTS

another proof of Shell leadership in lubrication

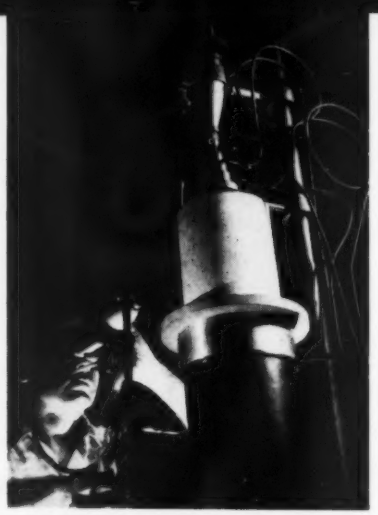
Tick **No 59** on reply card for further details

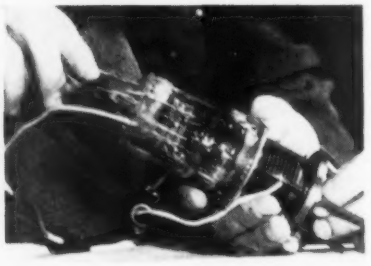
INDUSTRIAL NEWSDESK

ELECTRICITY DIRECT FROM HEAT

—four US approaches

Scientists in the US have developed several promising direct conversion devices; thermal efficiencies up to 12% are now being reached and some will be ready for small scale use inside two years. Workers at the General Electric Co (below) have studied many different sizes and types of thermionic converter tubes; best efficiency yet is 8% but 15 to 25% is hoped for soon. Westinghouse have developed a mixed valence oxide to stand 3000°F and are using it in a direct conversion reactor design. It is prepared in special furnaces (top right). Below, an Allis-Chalmers scientist watches as two bulbs are lit by one of the company's fuel cells which consist of electrodes coated with a catalyst, in an electrolyte. Hydrogen and oxygen are fed in to produce free electrons by a chemical reaction. The Massachusetts Institute of Technology's thermo-electron engine (bottom right) uses hot and cold plates in a vacuum tube.





and tape-editing has already been installed at Erith for programme preparation, so that the new digital machine can be put to full use as quickly as possible.

Elliott's form nuclear firm

As briefly announced in *Worldview* last month the new company Elliott Nucleonics Ltd is to assume responsibility for the whole of the activities in the nuclear field of Elliott Brothers (London) Ltd. Mr G. C. Fairbanks, joint General Manager of Elliott-Automation Ltd, and a Director of Elliott Brothers (London) Ltd, and Mr M. V. Needham, have been appointed directors. The company will carry out the instrumentation and control work being done by the group for the four CEGB nuclear power stations and the design and manufacture of the control rod mechanisms for the advanced gas-cooled reactor at Windscale.

British coffins may sell abroad

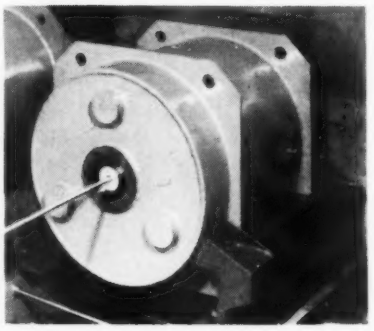
Atomic energy authorities of several countries are showing interest in a British protective container for transporting or handling radioactive isotopes. Originally developed by Westover & Co Ltd for Harwell and Imperial College, London, the isotope coffin basically resembles a small boiler measuring about 2 ft long and 2 ft 3 in. dia. The outer casing is made from ¼ in. thick boiler plate. Lengthways, through the centre of the container, is a stainless steel tube into which the radioactive isotope—which itself is contained in a 9 in. long cylinder—is fitted. Between the tube and the outer casing are about two tons of commercial pig lead. Eight in. long plugs—also lead—fit into each end of the central tube and they are filled with brass sheaths which lock them in place once

continued from p 99

nitrogen shielded, three-shell construction with evacuated powder as insulation. A new insulation, recently reported by private industry, has a thermal conductivity low enough to eliminate the need for liquid nitrogen shielding. During transportation, isolation of the container allows the pressure to rise to some fixed design value based on travel time and rate of heat transfer, accomplishing 'no-loss' storage. Stainless steel meets the requirements for the pressure vessel, and carbon steel or aluminium are the preferred metals for the outer ambient-temperature vessel. The two methods suggested for transferring into compressed storage facilities are: **1.** If an adequate pressure is maintained in the container, helium can be forced through a heat exchanger, warmed to ambient temperature, and then piped to gas storage cylinders through conventional compression equipment, or, **2.** a low-temperature pump can be used to force the helium through a heat exchanger to compressed-gas storage.

GEC expands computer group

Over £140,000 is being spent by the Atomic Energy Division of the General Electric Co in expanding its computer facilities. In addition to an American Pace analogue computer due for delivery at the end of February a Ferranti Mercury has been ordered. The Pace has the advantage that it can be coupled to the Division's existing specially-designed Elliott analogue computer, and the two machines will be 'particularly valuable' say the company, in carrying out the necessary calculations for its advanced reactor programme. Pending the installation of the Mercury, Ferranti's computer services are being extensively employed.



This 2 ft long 2¼ ft dia coffin for radioisotopes carries 2 tons of lead inside its ¼ in. boiler shell

the isotope has been inserted in the tube. Another tube, of ¼ in. hot drawn mild steel, surrounds the central core and prevents any buckling during the manufacture of the container, particularly

A matter of simple division?

No, Professor! Dividing floor space can be really difficult. You've got to make sure each square foot is used to the most efficient advantage. And what about changes? Expansion? New layouts?

Elementary, when you divide with NSE—the non-vibrating steel and glass partitioning that looks permanent but can be altered in no time to make offices, passages and bays of different sizes. It is inexpensive—*even cheaper than wood!*

NORWOOD STEEL EQUIPMENT LTD

Makers of steel partitioning, steel plenum lockers etc.

Please write to Dept. H.H. for free illustrated brochures:
"STEEL PARTITIONING", "STEEL OFFICE FURNITURE and LOCKERS"
or "STEEL STORAGE EQUIPMENT"

149 Borough High Street, London, S.E.1
HOP 5033
and at Manchester, Birmingham and Bristol

Tick **No 60** on reply card for further details

when the main lead shielding is poured. The whole set-up is designed for safe containment of up to 25 curies. In view of the fact that the equipment sometimes remains immersed in water for weeks on end, Westover & Co Ltd have finished the outer casing with a chemical-resisting resin against corrosion.

US Texas, M & C merge

The directors of Texas Instruments Inc of Texas, and Metals & Controls Corporation of Massachusetts, have agreed on a merger. The proposed plan is being submitted to the stockholders of both companies. Texas Instruments, now twenty-nine years old, makes electronic and electro-mechanical systems and is a leading manufacturer of semiconductor devices, with plants in Dallas and Houston, Texas, and Bedford, England. Metals & Controls, a forty-two-year-old company, with approximately 3000 employees, has three main activities: clad metal products for use by the electrical, nuclear, jewellery and other industries, thermostatic controls for industrial and motor control uses and nuclear fuel elements and cores.

In Brief

● **Computer service** The Manchester College of Science and Technology is introducing a service for structural engineers, based on the use of a Mercury.

● **A traveller's tale** Recently back from a several weeks' 3000-mile sales tour of Holland, Germany, Austria, Italy and France, where he appointed head agents, F. Winston Reynolds, chairman and managing director of Winston Electronics, said the main criticism of British exporters he encountered is that not enough technical information is given about the products. He added that his journey was much eased by the new international carnet for taking equipment through customs.

● **Semiconductors cheaper** Texas Instruments Ltd have announced the third price reduction within twelve months. Prices of transistors and rectifiers have been reduced, some by as much as 35%.

● **Mallinckrodt Chemicals** This company, the pioneer uranium fuels processor in the US, has established a separate company, Mallinckrodt Nuclear Corporation, to carry out its privately-owned nuclear fuels business.

● **Johannesburg Show** The British Electrical and Allied Manufacturers' Association's Southern African Overseas Committee is staging an exhibit in the UK Pavilion at the Rand Easter show to be held in Johannesburg, March 17–27 next. The exhibit, called 'Power for Progress', will include three sections: Power from the Atom, Power from the Earth, Power from the Hills.

● **New No 2 for AEI-JT** Cyprus born Selchouk A. Ghalib has moved up from chief engineer to general manager of The AEI-John Thompson Nuclear Energy Co.

● **Calder control** Apparatus for new remote control equipment fitted at Calder Hall recently included a special Power Auxiliaries Plessiflex 80 ft stainless steel hose. It is seamless, with a bore of over 2 in. and carries seven internal hoses to provide hydraulic power and other services. They are all braided in stabilized stainless steel wire and the hose is also used as the crane rope for carrying the weight of the equipment.

● **Team to view US reactors** A party from 20th Century Electronics Ltd is to tour American firms making reactors for research and training.

NAMES IN THE NEWS

Joint managing director of Lancashire Dynamo Holdings Ltd **Mr D. C. Lorkin** now becomes managing director on the resignation of joint managing director **Mr S. F. Steward.** Mr Steward has become director-designate of BEAMA.

From the beginning of the New Year **Mr Cecil Dotson** of Dallas, Texas, became chairman of the board of Texas Instruments Ltd, Bedford.

Wayne Kerr Laboratories announce that **Mr G. C. C. Miller,** formerly with Ferranti's, will occupy their newly created post of sales engineer for the north of England.

Sales director of British Ermeto Corporation **Mr Charles Watson** retired from the company at the end of 1958.

Mr A. J. Gray has been appointed general works manager of Ferranti.

AEI turbine generator division have appointed **Mr P. A. J. Manley** assistant superintendent, large turbine department.

Mr L. M. T. Castle, a director and secretary of Stewarts & Lloyds has become managing director, finance and general administration.

English Steel Corporation Ltd announce the appointment of **Mr W. E. A. Redfearn,** who is chairman of the Alloy Steels Association and on a number of other committees, as a director of the company.

Fluidrive Engineering's managing director for 30 years **Mr Harold Sinclair** has now retired, new managing director is **Mr Leonard Watson.** Mr Sinclair remains chairman of the board.

Following the integration of GEC's Witton and Erith works under the control of assistant managing director **Mr A. L. G. Lindley, Mr T. H. Kelsey** has been made assistant general manager and **Mr J. W. Laing** chief engineer responsible for the rotating machines, switchgear, transformer, rectifier and traction divisions.

Mr P. D. Hall and **Mr J. R. Pickin** have been appointed managers of Ferranti's computer and electronics departments respectively.

BICC's regional manager, London, is now **Mr G. N. Blades** who succeeded **Mr E. A. Sayers.**

The APV company have appointed **Mr H P. N. Benson** to be deputy managing director.

Mr R. Craig Wood has been elected a director of AEI.

Mr H. G. Nelson, managing director of English Electric has been appointed deputy chairman of the following subsidiary companies: D. Napier & Son. Marconi's Wireless Telegraph, Marconi Instruments, English Electric Valve Co. Vulcan Foundry and Robert Stephenson & Hawthorns Ltd.

Mr W. Forbes Ritchie until recently chief engineer of the Consolidated Pneumatic Tool Co has been appointed manager of factory operations.

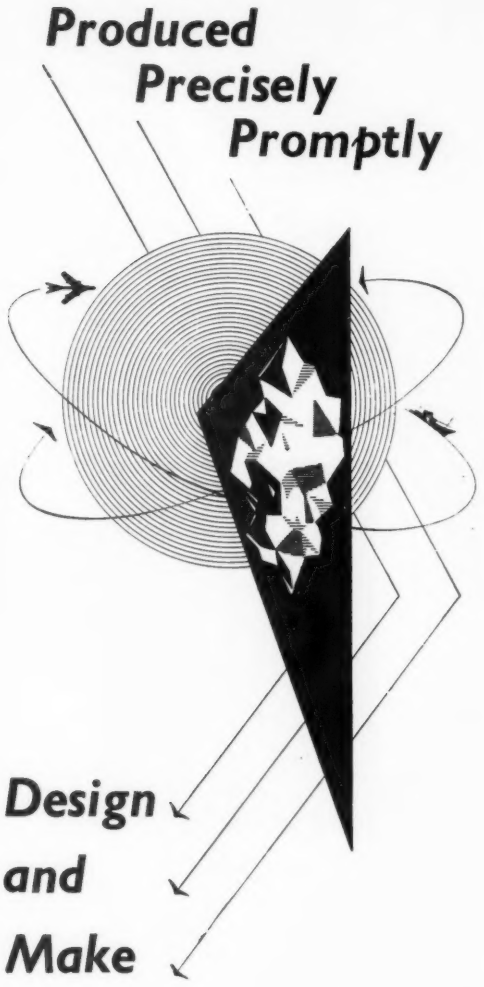
Mr J. A. Marsh, formerly with A. C. Wilson & Partners has joined Palatine Tool & Engineering Co (Surbiton) Ltd as chief engineer.

W. E. A. REDFEARN

C. DOTSON

S. F. STEWARD

H. G. NELSON



Our Research, Development and Design facilities and the most up-to-date equipment, which includes 16 Jig-Borers, enables us to execute the design and production of Special Purpose Mechanisms, Assemblies and Machines. Close Tolerance Gauges, Models, Test Rigs, Pumps and Components to timed schedules are at YOUR service—and, of course, Precision Toolmaking.

Whenever TIME & ACCURACY matter you can depend upon us!...

Serving Industry, M.O.S., Admiralty and U.K. Atomic Energy Authority

Our Technical Department is available for consultation at all times

PREMIER PRECISION LTD

Research & Development Engineers & Toolmakers

WESTERN ROAD, BRACKNELL, BERKS

Tel: BRACKNELL 1002-3-4-5 **TELEX 84128**

They said...in America this month

points from papers, speeches, conferences

Eggs and baskets

There is still not enough definitive information to understand precisely the potential of any one reactor type, much less of all of them, John Floberg, AEC Commissioner, reiterated before the Winter Meeting of the American Nuclear Society. A decision to concentrate on maximum development of a single promising reactor type would be contrary to what was said at the outset about the US programme, that it is developmental, and not aimed directly at production. The British effort started out largely as a production programme. 'They were forced by the pressure of urgency to concentrate on repetitive construction of a single type of reactor. It is a fairly safe conclusion that the reactors of the future, even the fairly near future, will not be of this type. The British are themselves now beginning to work on other types. This is not to say that the British made a mistake: in their circumstances the decision may have been both necessary and wise, but in our circumstances a similar concentration would, in my opinion, be a serious mistake.'

On the other hand he thought, the US would not be justified in following every concept which shows promise. 'And we are thus faced with a question of making a rather difficult set of judgments somewhere between unacceptable extremes. I reveal no secret if I tell you that on this question there is wide disagreement among those from whom we receive advice, and also that the Commissioners themselves compromise their individual views in settling on agreed Commission programmes.'

AEC clogged by paper?

Possible bottlenecks in the Atomic Energy Commission's research and development programme are being investigated by the staff of the sub-committee on Research and Development of the Congressional Joint Atomic Energy Committee, according to Melvin Price, sub-committee Chairman, and C. Holifield, Chairman of the sub-committee on Legislation. 'Particular emphasis is being given to projects which especially interested the Joint Committee during its consideration of the 1959 authorization legislation,' they said in a recent letter to the AEC. 'The Committee has become increasingly aware of delays in contract negotiations, and delays in acting on requests by the Joint Committee and the Congress. We are interested in determining if these delays are due to mounting AEC paper work, and possible increasing centralization in AEC activities.' To date, the sub-committee members and staff have held several meetings with Commission officials at the Washington headquarters in Germantown, Md, and have made trips to installations in the field in an effort to determine the extent of red tape in AEC operations. 'We expect to continue the study for the next several months before drawing any conclusions.'

WILLARD LIBBY

Turn them inside out

Chemists must speak up

The most important contributors to atomic energy development in the next few years may be the chemists, maintained Dr Willard Libby, AEC member, in a recent address to the Manufacturing Chemists' Association in New York. Their problems have been increased by the introduction of plutonium as a reactor fuel, he said. 'We have learned a good deal about plutonium metallurgy, particularly the kind of metallurgy required for the fabrication of metal parts, but we have scarcely studied the effect of irradiation upon the crystal structure of plutonium and its alloys, particularly for large amounts of radiation. Furthermore, many of the possible plutonium-uranium alloy compositions are brittle intermetallic compounds which cannot be fabricated at all easily. It is possible that the chemist's viewpoint might lead to a useful application in the region where conventional metallurgy would be unpromising. Similarly, there has not been very much exploration of the use of compounds of plutonium as reactor fuel, and the chemist has a real job here.

'I also hope the chemical industry will pursue the possibilities of using the materials of the atomic industry in new ways, which will not be thought of except by chemists or people closely associated with the chemical manufacturing industry,' he went on. 'I should like to encourage exploration of the possibilities of using carbon-14 or tritium at low levels. The USAEC has an appropriation this year of five million dollars to further uses of isotopes in industry, and some of this money can be spent for research and development of such applications.

'The direct use of fission fragments suggests some exciting possibilities. The concept of using the kinetic energy fission fragments to catalyse chemical reactions leads one to revolutionary designs for reactor fuel elements. In the past, fuel elements have been designed to prevent the escape of fission fragments; the catalysis concept calls for just the reverse; the uranium should be on the surface of the fuel element so that the recoils will be shot into the stream of mixed coolant and chemical raw material as it flows by.

'Another idea about which I am enthusiastic is using reactors to make new chemicals. We have only to suspend or dissolve in say, the OMRE, the chemicals we propose to react, pass them through the intense gamma and neutron fields within the reactor and subsequently recover the product by conventional chemical separation methods.'

Have ship proposals foundered?

An intention to follow up in the next Congress the developments in merchant marine uses of atomic energy was expressed recently by Herbert Bonner, Chairman of the House Committee on Merchant Marine and Fisheries. Calling for a report from the Secretary of Commerce, he said 'I am becoming greatly concerned that we do not have a programme to carry on the work that was started with the *Savannah*. Plans are in the formulation stage in both the AEC and the Department of Commerce, but there seems to be nothing firm in the way of administration policy to put these plans into execution. This Congress, with wide departmental support, authorized the construction of a nuclear-powered icebreaker. There were proposals for the application of nuclear energy to a tanker. There were offers by private industry to participate in atomic ship development. None of these proposals have got anywhere.'

nucleol

radiation resistant lubricants for the atomic age

A range developed and perfected by Wakefield-Dick Research

Conventional oils cannot live in conditions of atomic radiation. Such conditions are inseparable from certain parts of any mechanism designed to produce power from nuclear fission.

This, and other allied lubrication problems, was the challenge which faced oil technologists everywhere. And, as so often in the past, Wakefield-Dick's research team produced the answer. An entirely new series of oils and greases, resistant to radiation and named "Nucleol", is now available to lubricate the wheels of this Atomic Age.

INDUSTRIAL WAKEFIELD-DICK LUBRICANTS

A Wakefield-Dick research chemist investigating the effects of radiation on lubricants.

Two examples of the NUCLEOL range

NUCLEOL 522 A radiation resistant lubricant based on selected mineral oils of high aromaticity and containing special inhibitors.

NUCLEOL G 114 A grease gelled with a new compound, and specially inhibited. Designed for the lubrication of control actuator bearings operating at the lower radiation levels.

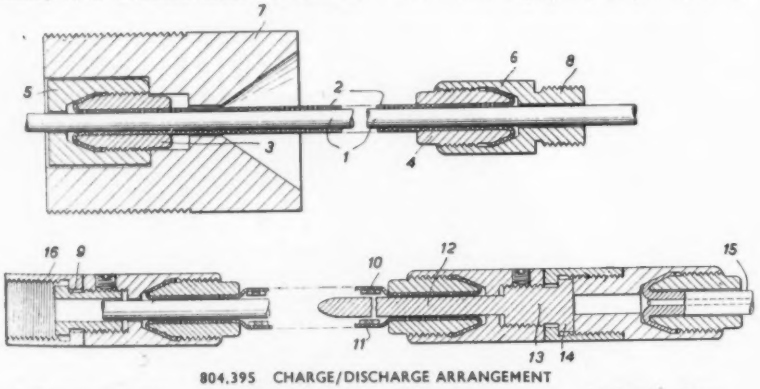
Tick **No 62** on reply card for further details

NEW IDEAS
nucleonic patents

Handling the thermocouple . . .

In order to charge and discharge a fuel element with its thermocouple attached, the use of a load-bearing, flexible sheath, formed by a stainless steel wire helix, is proposed by the UKAEA (this could be Calder Hall). The thermocouple cable, 1, passed through the sheath, 2, which is attached—via screwed tapered pins, 3, 4, and clamping nuts, 5, 6—at one end to a lifting block, 7, and at the other to a coupling boss, 8. The lifting block screws into a section carrying the fuel element itself. The free end of the cable is attached to a terminal block. The boss, 8, connects with another coupling, 9, in which is clamped another length of hollow, flexible cable, 10, sheathed in stainless steel braiding, 11. Into the other end of the cable, 10, fits a spigot, 12, connecting via a plug, 13, and a coupling flange, 14, to a stainless steel lifting wire, 15.

For charge/discharge operations, the cable, 1, is detached from its terminal block, the assembly of the lifting wire to the cable, 10, made and the free end of the cable fed through. The union nut, 16, is then tightened to take the weight of the element.



804,395 CHARGE/DISCHARGE ARRANGEMENT

1 Thermocouple cable
2 Flexible sheath
3 & 4 Screwed, tapered pins
5 & 6 Clamping nuts
7 Lifting block
8 Coupling boss
9 Coupling
10 Flexible cable
11 S.S. braiding
12 Spigot
13 Plug
14 Coupling flange
15 S.S. lifting wire
16 Union nut

804,395 Improvements in or relating to nuclear reactors *United Kingdom Atomic Energy Authority* (inventors: H. C. Knight and H. Morris) Appn: June 23, 1956 Pubd: Nov 12, 1958

. . . and fixing it on

Welding or brazing cannot be used for fixing a thermocouple pair to a fuel can because it involves association of at least three differing materials plus fluxes. In this alternative method, the can has one eccentric fin root near the base through which a hole, 0·0635 in. dia, is drilled, so that the minimum thickness between the hole and the sheath proper is the same as the normal fin thickness. The thermocouple cable, nominal dia 0·0625 in., containing the hot junction is pushed through the hole clear of the fins, flattened to 0·070 in. over a length of 0·1 in., and then pulled back under load just inside the hole. The cable is led along the fuel element in slots cut in the fins.

806,490 Improvements in or relating to nuclear reactors *United Kingdom Atomic Energy Authority* (inventors: P. P. Guneratne, M. Young and G. H. French) Appn: July 27, 1956 Pubd: Dec 23, 1958

Porous fuel

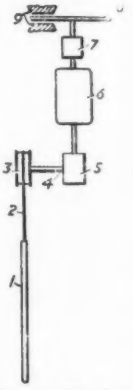
The problem of xenon poisoning is the target in this invention by Degussa in which the fuel elements are porous and uncompacted with at least 5% pore volume and exposed directly to the coolant. The elements may take several forms, all of large surface/volume ratio. Particularly recommended is a compound form made up of rods, disks or tubes, but any small shape giving a uniform and reproducible packing density is possible. Thus a graphite, beryllium, or zirconium container, which can fill the whole reactor chamber, is filled with either rods or such shapes as balls, Raschig rings, saddles, etc. In an alternative arrangement the container can be in the form of vertical tubes, filled with spherical fuel which can be continually charged and discharged.

Suitable compounds for the fuel are oxides, carbides, silicides or fluorides of uranium and plutonium.

806,430 Fuel element for nuclear fission reactors *Deutsche Gold-und Silber-Scheideanstalt Vormals Roessler* Appn (in Germany): June 2, 1956 Pubd: Dec 23, 1958

Clutch-free control rod

Combined control and shut-off rod by Reyrolle, a member of the Nuclear Power Plant Company, is suspended by a flexible chain or cable from a windlass drum, mounted on the horizontal spindle of a reduction gearbox which is driven by a variable speed electric motor with no clutch between the rod and the motor. A second gearbox connects the other end of the motor shaft to an electromagnetic induction brake. For emergency shutdown, the motor is de-energized and the rod allowed to fall, under gravity but controlled by the brake. The inertia of the driving train constituted by the motor, gearing and moving parts is sufficiently low for it to fall rapidly enough while remaining coupled to the motor, driving the de-energized motor in reverse through the gearing. Final deceleration is produced by the brake whose torque is automatically raised with the rod's position by means of the variable-ratio gearbox. Absence of clutch is claimed to lead to great reliability.



806,409 IMPROVED CONTROL

1 Control rod
2 Flexible cable or chain
3 Windlass drum
4 Reduction gearbox
5 Gearbox
6 Electric motor
7 Variable-ratio gearbox
8 E-m induction brake
9 Brake magnets

806,409 Improvements in or relating to control systems for nuclear reactors *Reyrolle & Co Ltd* Appn: Sept 30, 1955 Pubd: Dec 23, 1958

In brief

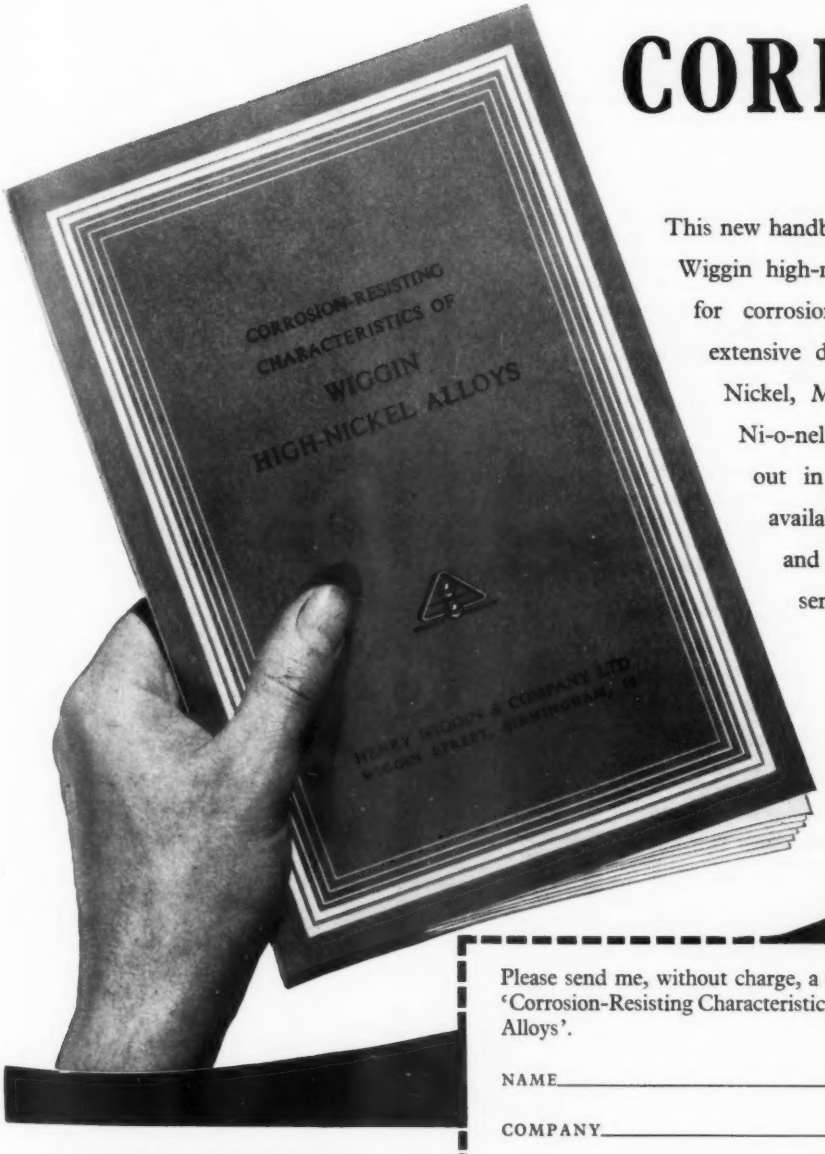
Feature of the design for a **concrete pressure vessel** by GEC described in 800,388 is the joints between the central annular section and the two end closures, to take up relative lateral movement. Constructed as dry joints during fabrication, they are formed of mild steel bars set in concrete.

Special composition glass with high resistivity and low deformation temperature for providing an insulation **coating for uranium** to prevent reaction with an aluminium can is described in 802,639 of BTH. It is free from boron, to prevent neutron absorption, and silicon, which makes chemical processing difficulties. Three mixtures detailed contain P_2O_5, BaO, Al_2O_3, and either Na_2O or K_2O.

These abstracts are made from British Patent Specifications with the permission of the Controller of Her Majesty's Stationery Office. Complete specifications can be obtained from the Patent Office (Sales Branch), 25 Southampton Street, London W.C.2. 3/6 a copy (including postage, inland and abroad)

Knowing where to find the answers on

CORROSION



This new handbook describes in detail the many Wiggin high-nickel alloys specially developed for corrosion-resisting duties. It includes extensive data on the properties of 'AT' Nickel, Monel, Inconel, Corronel B and Ni-o-nel, and gives results of tests carried out in many corrosive media. It is available, without charge, to designers and chemical engineers. May we send you a copy?

Please send me, without charge, a copy of your publication 'Corrosion-Resisting Characteristics of Wiggin High-Nickel Alloys'.

NAME_____

COMPANY_____

_____

Publications will be sent to private address, if preferred.

NP.

WIGGIN

***KNOW* NICKEL ALLOYS**

'MONEL', 'INCONEL', 'CORRONEL' AND 'NI-O-NEL' ARE REGISTERED TRADE MARKS

HENRY WIGGIN AND COMPANY LIMITED, WIGGIN STREET, BIRMINGHAM 16

TGA C2

CATALOGUES AND BULLETINS

Water gauges Bestobell prismatic water level indicators and sleeve-packed gauges are described with diagrams in brochure from Bell's Asbestos & Engineering.
Tick **No 208** on reply card

Armoured heating Preheating and stress relieving welding equipment manufactured by Electrothermal Engineering is fully described with technical details in leaflet 321.
Tick **No 209** on reply card

Square wave polarograph Developed by a member of Mervyn Instrument's staff working at Harwell it is claimed that the Mark III Mervyn-Harwell polarograph is 200 times as sensitive as conventional instruments. Leaflet describes.
Tick **No 210** on reply card

Air filter gauge Useful instrument which gives an automatic warning when filters should be changed is only 1½ in. x 1½ in. x 3 in. high. Specification sheet available from the manufacturers Air Control Installations.
Tick **No 211** on reply card

Silicone insulants Properties and applications of silicone insulants are described in technical paper by J. D. Hayden and B. F. W. Hayward of Midland Silicones.
Tick **No 212** on reply card

Aluminium sheet Northern Aluminium Co have produced a new solid aluminium sheet which they call 'Noralduct.' It has internal systems of passages and ducts and is therefore particularly suitable for heat transfer equipment.
Tick **No 213** on reply card

Miniature relays Data book from Londex Ltd lists with technical details their products including relays, timers etc.
Tick **No 214** on reply card

Solenoid valves Dust-proof and flameproof solenoid-operated semi-balanced valves from Jones, Tate & Co Ltd are described in recent leaflet.
Tick **No 215** on reply card

Silencer For suppressing the constant whine associated with turbo-blowers or high-speed fans Vokes Ltd offer the NCSP 3 splitter absorption type silencer which they claim can operate at temperatures as high as 1000°F.
Tick **No 216** on reply card

Colloidal graphite Special atomic energy number of 'Prospects' published by Acheson Colloids features the use of their products on equipment designed for Berkeley and Bradwell.
Tick **No 217** on reply card

ICI rubbers Silicone rubbers widely used in industry are of particular use in the nuclear industry where rubbers are often required to withstand high temperatures. Brochure from ICI includes summary of physical and electrical properties.
Tick **No 218** on reply card

Shielding material Leaflets can be had on Barytes Shielding Products—radiation shielding construction elements in the form of bricks.
Tick **No 219** on reply card

Gas analysers List 144/C from Cambridge Instruments describes a range of indicators, recorders, and controllers for use with their automatic gas analysers of the thermal conductivity type. Also included are details of units for the supply and standardization of the katharometer-bridge current.
Tick **No 220** on reply card

American centrifugal pumps General description and capacity ratings of liquid metal, liner-motor and mechanically-sealed pumps is included in bulletin of pumps suitable for nuclear work from Byron Jackson Pumps.
Tick **No 221** on reply card

Fork-lifting truck Cleco Electric Industries have colour leaflet available about their trucks—capacities are from 1 to 6 tons.
Tick **No 222** on reply card

Pressure die casting Cutting costs with pressure die casting in Hiduminium is the subject of leaflet from High Duty Alloys.
Tick **No 223** on reply card

Platinum apparatus Publication from Johnson, Matthey & Co makes a comprehensive survey of the platinum laboratory apparatus and electrodes in the JMC range.
Tick **No 224** on reply card

FEBRUARY DIARY

ICE Institution of Civil Engineers, IMechE Institution of Mechanical Engineers, IEE Institution of Electrical Engineers, IChemE Institution of Chemical Engineers, IP Institute of Physics, PS Physical Society, SCI Society of Chemical Industry, IM Institute of Metals, IMet Institution of Metallurgists, IMM Institution of Mining and Metallurgy, IPE Incorporated Plant Engineers, SIT Society of Instrument Technology, BritIRE British Institution of Radio Engineers, RSH Royal Society of Health, IR Institute of Refrigeration.

MONDAY 2
LONDON SCI The selection and control of semi-conductors 6.30 at the Society

TUESDAY 3
LONDON IMechE An experimental investigation of the pressurized air-lubricated journal bearing in the high-speed range *N. F. Rieger* 6.00 at the Institution
MANCHESTER IChemE Effluent disposal and air pollution 3.00 Chemical Engineering Building, College of Science and Technology, Jackson St

WEDNESDAY 4
LONDON BNEC A radioactive corrosion probe *D. Anson* 5.30 at the Institution of Civil Engineers, 1–7 Gt George St, SW1

FRIDAY 6
LONDON IEE Problems of storing transient phenomena for subsequent analysis *Dr P. Bauwens, P. Styles* 6.00 at the Institution
BIRMINGHAM IChemE AGM followed by Principles of selected dimensional systems and units in chemical engineering *A. Klinkenberg* 2.30 Birmingham College of Technology, Gosta Green

TUESDAY 10
LONDON SCI The extraction of thorium *W. D. Jamrack, R. A. Wells, J. H. Buddery* 6.00 at the Society

WEDNESDAY 11
TREFOREST BritIRE Industrial television *E. A. Naef* 6.30 Glamorgan College of Technology
WOLVERHAMPTON BritIRE Some aspects of the control of nuclear reactors *C. W. J. Newman* 7.15 Wolverhampton and Staffordshire College of Technology

THURSDAY 12
LONDON ICE Symposium on mass transfer *Prof F. H. Garner, J. F. Davidson, P. H. Calderbank, G. G. Hasleden* Church House, Westminster, SW1
Registration forms obtainable from the Institution's general secretary

MONDAY 16
CHELTENHAM SIT Instruments for nuclear reactors *T. D. H. Andrews* 7.30 at the Rotunda

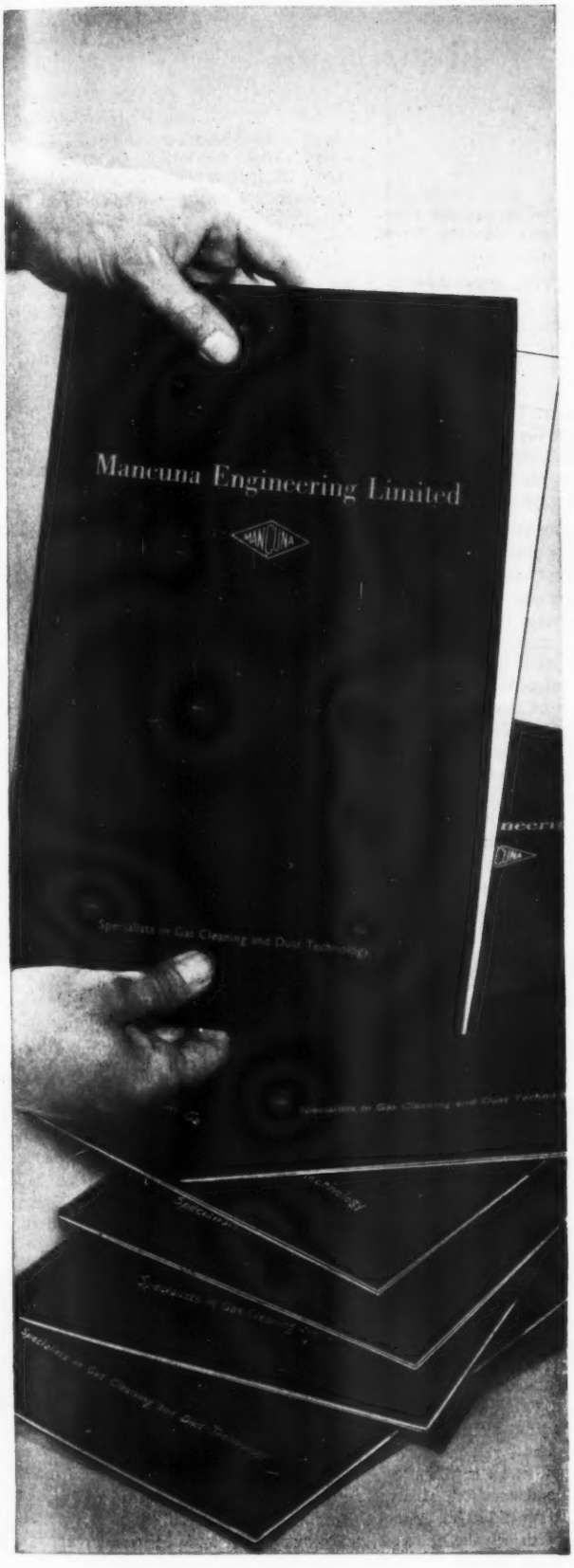
THURSDAY 19
NOTTINGHAM SIT Data collection and processing 7.00 Nottingham and District Technical College, Shakespeare St

FRIDAY 20
LIVERPOOL BritIRE Electronic welding controls *C. R. Bates* 7.00 at the University Club

TUESDAY 24
LONDON SIT Symposium on automatic weight control in industry *A. L. Hendon, G. C. Chapman, R. N. Settle, E. I. Lowe, M. J. Harris* 6.00 Manson House, Portland Place, W1

WEDNESDAY 25
LONDON BritIRE Patents and the radio engineer *E. D. Swann* 6.30 at the Institution
CARDIFF SIT The development of flow measurement *B. L. Thurley* 6.45 Physics Lecture Theatre, Welsh College of Advanced Technology

FRIDAY 27
CHELTENHAM BritIRE Micro-miniaturization *G. W. A. Dunmer* 7.00 North Gloucestershire Technical College
GLASGOW SIT Data handling in the process industries *A. Parsons* 7.15 Scottish Building Centre, 425 Sauchiehall St



Memorandum on a dangerous subject

The creation of dusts infinitely more dangerous than anything previously known to mankind has given impetus to a 'new look' at the problems so far experienced, and the methods and equipment available to combat these problems. Mancuna Engineering Limited have been in the forefront of those few Companies who have recognised the exceptional nature of the demands which would have to be met in nuclear energy installations. Their latest memorandum describes the technical and scientific approach being applied to gas cleaning and dust collection and provides the nuclear energy engineer with an appreciation of the equipment available to him. *A brief request on your firm's letterhead will ensure you a copy.*

MANCUNA ENGINEERING LIMITED

Specialists in Gas Cleaning and Dust Technology

DENTON · MANCHESTER

Phone: DENTON 3965 (5 lines)

London Office: 59 VICTORIA ROAD
SURBITON · SURREY
Phone: Elmbridge 9793

Tick **No 64** on reply card for further details

Tick **No 226** on reply card

HEAT EXCHANGERS

By W. HRYNIZAK, D.Sc., Dip. Ing.
C. A. Parsons & Co., Ltd.

This book is not concerned with the process of heat transfer itself, but with the apparatus performing this transfer and the best way of designing and fitting it into a gas turbine so as to obtain, depending on its applications an economical unit. It is felt that the manner in which the thermodynamical optimization of the gas turbine air preheater has been treated, will be of particular interest in connection with supercritical steam cycles and nuclear power applications.

The book will supply an authoritative and long felt need to the engineer and will not be without interest to the physicist who is more and more becoming involved in direct applications of thermodynamics. *Price 63s.*

GLOVE BOXES and SHIELDED CELLS

Editor: G. N. WALTON, M.A.
A.E.R.E. Harwell

In the United Kingdom Atomic Energy Authority, operating experience in handling bulk quantities of radioactive materials in the laboratory has been mainly obtained with α-active materials such as plutonium. Consequently in the choice of papers for the 1957 Harwell Symposium, of which this book is a record, most attention was given to the design and operation of equipment which has been developed for handling these materials. Experience gained in France, and in the U.S.A., as well as in the Research, Industrial, and Weapons Group of the U.K. was covered as fully as possible.

The increasing experience being obtained in handling irradiated fissile materials and high β and γ-active sources is reflected in the number of papers included here on the development and use of equipment for these sources which require shielding.

Many more people, in a large number of countries, will be using these techniques in the next few years and it is essential that a fund of information on safe methods be built up and made easily accessible to all. This publication from U.K.A.E.A., Harwell, will prove an invaluable guide for those engaged in meeting these needs. *Price 95s.*

Full details available, post free, from

Butterworths Scientific Publications
4 & 5 Bell Yard
London, W.C.2

Book Reviews

International

Manual of safe handling of isotopes International Atomic Energy Agency, Vienna 1958. Price 6s

As yet it is difficult to decide how far the cross currents of international politics will circumscribe the efforts of the International Atomic Energy Agency. Certainly it is clear that the original vague, but ambitious, objectives are unlikely to be reached. Up to now their greatest success has attended their preparations for educational developments and the study of public health questions related to nuclear science.

This first technical publication to be issued by the agency deals with the very important and topical matter of a code of practice for the use of radioactive substances. This subject is currently receiving attention in many countries and an international code of practice would indeed be most valuable. Admittedly, much of the spade work has already been prepared on an international basis by the International Committee on Radiological protection and a very substantial appendix to this report is abstracted from the current ICRP recommendations. However, the ICRP report is principally concerned with permissible levels of exposure to radiation and only incidentally with a code of practice ensuring that these are not exceeded.

The agency report has been prepared as a guide to authorities drawing up local codes of practice and to users of radioactive substances. It presupposes a reader of some scientific training and deals rather with principles and regulations than the more practical details. Questions of equipment and methods of monitoring are properly excluded. The recommendations generally follow the best practice in countries already making extensive use of radioactive substances.

The present version of the report would profit by further editing. For example, under personal protective measures, pipetting and glass blowing by mouth in active laboratories is prohibited, although ordinary wash bottles are not mentioned and a more general ban on all mouth-operated equipment is not included. Again, temporary protection from contamination by strippable paint is referred to under decontamination but not described in an earlier section dealing with the decoration of active laboratories. It would also seem desirable that the needs of the intelligent, but not necessarily previously experienced, scientist should be kept in mind. A section devoted to aerial monitoring omits to forewarn the reader of the radon decay products he will inevitably encounter. Indeed quite experienced staff are often disconcerted when first they make such a measurement!

Notwithstanding a number of similar items of detail the document marks a valuable step towards an accepted international code of practice for the handling of radioactive substances.

A. G. Maddock

Polyglottic

Elsevier's Dictionary of Nuclear Science and Technology W. E. Clason London 1958: Van Nostrand 914 pp Price £7

During a visit to a nuclear physics research institute in Amsterdam last year a young Dutch scientist was showing a rather mixed party a new glove-box. 'What,' asked one of the party, 'do you call this in Dutch?' The young man looked puzzled for a moment then replied, 'why glove-box, of course.' I only relate this to show how far English has become the language of nuclear energy. This does not necessarily mean that all atomic scientists are perfectly fluent in English or that it will ever replace national tongues. But it does show I think that in the West at any rate it has become the basic nuclear language and that other languages tend to follow it. And this book shows that too.

The author, who is the head of the translation department at Philips' Eindhoven works, has produced a work which should be a pride and joy to any technical librarian. It includes about 4000 basic terms first of all defined in English and then translated (with genders for nouns) in French, Spanish, Italian, Dutch and German right across two pages. Working from a foreign language you first look up the word in a separate section and this gives you the number in the basic table—a scheme which seems to work very well. The English definitions of the basic terms are taken from the best international sources and the extensive bibliography quoted gives some idea of the scholarship that went into them.

A diligent search for outlandish words failed to reveal any startling omissions. Even semi-slang terms are here included and cloaked in respectability. Words like 'scram,' 'kicksorter,' 'slug,' etc are all religiously translated. I wonder though

if my Dutch friend would understand if I asked him to explain his *veiligheidkast!*

C.D.

Radioactive

Chemische Reaktionen Ionisierender Strahlen edited by H. Mohler Aarau 1958: Verlag H. R. Sauerländer 299 pp Price DM30.80

In the summer of 1956 a colloquim was held at the University in Basel, devoted to radiation chemistry with special reference to its industrial applications. This is an edited record and as participation was international, it appears partly in German and partly in English.

Unfortunately radiation chemistry, and more especially applied radiation chemistry, is not a field in which a delay of two years in publication is tolerable. The enthusiastic, but uninformed, atmosphere suffusing the subject two or three years ago has given way to a much more sober assessment of the limitations of ionizing radiations. Until further discoveries are made radiation chemistry appears unlikely to gain much greater industrial importance than photochemistry.

The discussion of radiation sources leaves much to be desired; only the section on the Van de Graaff machine by Dr J. Moll shows evidence of real experience in the application of these sources. The tables of beta- and gamma-active isotopes is obscure in its conception, omits several commonly used species and contains misprints. The most valuable part of the book is that contributed by Dr Minder whose review of dosimetry and introduction to radiation chemistry are both very satisfactory. Both chapters include well-known tables of references to other sources of information.

Prof Charlesby's short chapter on the effects of radiation on polymers is almost entirely devoted to polyethylene. His description of these effects is excellent but the absence of a more quantitative treatment is both disappointing and surprising. However, the industrialist will find that the concluding pages of this chapter are, from his point of view, the most important in the book for in them the conditions for the economic application of ionizing radiations in an industrial chemical process are clearly established.

The last chapter on industrial applications is often quite naive and unfortunately very few of the examples considered are now receiving serious attention. The chapter is terminated, however, with a useful description of how to embark on a radiation research programme. It is a pity that this chapter does not include a more extensive list of references.

A.G.M.

Tick **No 227** on reply card

The Physical Theory of Neutron Chain Reactors

A. M. WEINBERG & E. P. WIGNER

The only comprehensive and up-to-date study of the entire field of nuclear reactor physics. This book gives a rigorous analysis of the mathematical and physical theory underlying the design of nuclear power reactors, and includes much new material. It presents the first detailed discussion of the physics of heterogeneous reactors and the first extensive treatment of resonance and high-energy reactors. Many applications of the theory to problems of reactor design are considered. This is a basic and essential text for nuclear physicists, nuclear engineers, and reactor designers. It will find a place in all major technological libraries. *Published for the University of Chicago Press.* 814 *pages* 147 *text-figures* 85 *tables.* £5 12*s.* 6*d. net.*

AGENT IN GREAT BRITAIN
CAMBRIDGE UNIVERSITY PRESS

Tick **No 228** on reply card

BOOK SERVICE

All the books reviewed in *Nuclear Power*, and all other scientific and technical books and periodicals from all over the world may be obtained from:—

BLACKWELL'S

BROAD STREET
OXFORD

Catalogues sent regularly on request

No. 694 PERIODICALS
Just Ready

NUCLEAR POWER BOOK INQUIRY SERVICE

If you would like to have details of a particular book or to know whether one is published on a specific subject, fill in this coupon and send it to us. We will then forward it to the appropriate publisher or bookseller who will answer your query.

NAME .....

ADDRESS .....

.....

Details please of books on the following subjects:

.....

.....

.....

.....

.....

send to **NUCLEAR POWER, 3 PERCY STREET, LONDON, W1, ENGLAND**

Thermal REFRACTORY CEMENTS AND POWDERS

We also manufacture an extensive range of Vitreosil Industrial Ware

Thermal Fused Alumina and Fused Magnesia Refractory and Insulating Cements are very simple to apply; water is the only additive necessary for mixing before application.

For base metal windings our C60 cement is ideal; for platinum windings our CC60 cement should be used. Molybdenum windings necessitate a silica-free cement, and our No. 101 cement is specially prepared for this purpose.

In addition, we have available Special Air-Setting Insulating Cements, which remain rock-hard up to 500°C.

Details of these special high temperature cements, and also of Thermal Fused Alumina and Fused Magnesia Powders will gladly be supplied on request.

TSL

THE THERMAL SYNDICATE LTD.

P.O. Box No. 6, Wallsend, Northumberland. **Telephone: Wallsend 6-3242**

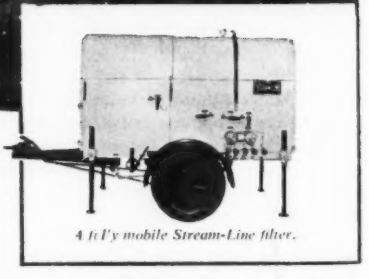
LONDON OFFICE:
12-14 OLD PYE STREET, WESTMINSTER, S.W.1. **TELEPHONE: ABBEY 5469**

STREAM-LINE FILTERS AND NUCLEAR POWER

The security of oil-immersed circuit breakers or transformers depends on the condition of the oil. In Stream-Line filters the engineer has at his disposal equipment specially designed for the complete removal of contamination in insulating oil and which meets the most stringent requirements. That's why Stream-Line filters have been specified for Chapel Cross and Berkeley, and are in wide use throughout the U.K.A.E.A. A single passage through a Stream-Line filter ensures the elimination of solid impurities, even the finest colloidal carbon; dehydration, including the removal of dissolved water, and de-aeration, including the removal of dissolved gases. A dielectric strength far above that specified for the highest quality new oil is achieved by a standard Stream-Line filter. Our research and development department will be glad to answer your queries. Write for Catalogue W. 1031.

A WORD ABOUT HIGH VACUUM

Stream-Line filters designed to operate under high vacuum can be supplied. Details are available on request of models yielding remarkable performances. For most requirements the standard Stream-Line filter gives precisely the service demanded.



4 ft Fly mobile Stream-Line filter.

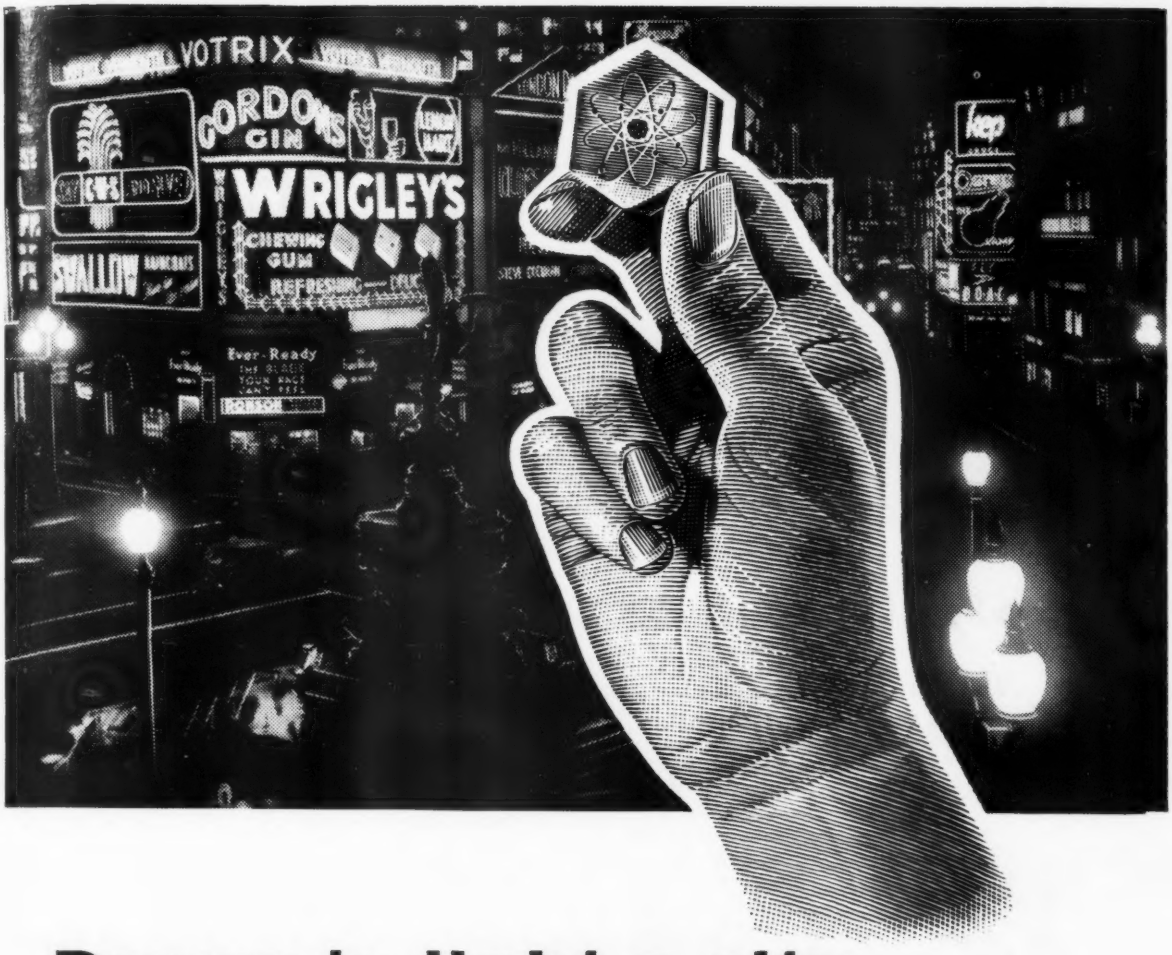
STREAM-LINE FILTERS

STREAM-LINE FILTERS LTD · INGATE PLACE · LONDON · S.W.8

A member of the VOKES Group

Telephone: MACaulay 1011

SF 29



Power to light a city . . .

. . . when "Acheson" slows the neutron

Out of the atom comes power—power for peace—power for industry—power to light our great cities.

The tremendous speed of fission particles must be greatly reduced so that man can harness their energy. To achieve this in the Calder Hall Reactors specially pure "Acheson" graphite is used as a moderator.

In close collaboration with the United Kingdom Atomic Energy Authority, 5,000 tons of "Acheson" graphite conforming to an exceptionally strict specification for purity were supplied from current output for the Calder Hall 'A' Reactor. This project demanded considerable production capacity backed by the highest technical skills and experience gained from many years producing "Acheson" graphite for the British Chemical, Electronic and Mellallurgical Industries.

Now at the threshold of a New Age of Atomic Power, British Acheson are already ahead with immense expansion programmes to provide "Acheson" graphite for the new demands of Atomic Energy. In 1958 present capacity at Sheffield works will be increased by 200 per cent.

British Acheson Electrodes Limited is continuing to anticipate the changing trends and new demands of British Industry.

ACHESON GRAPHITE
TRADE MARK

The term Acheson is a registered trade mark

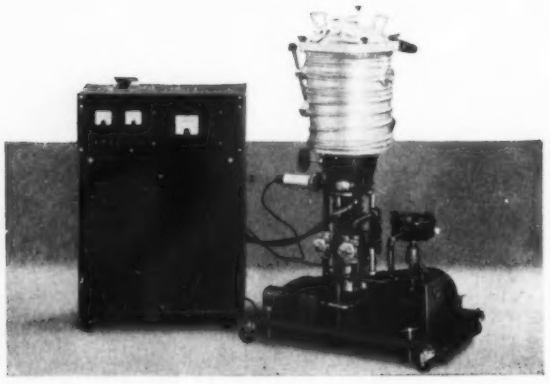
BRITISH ACHESON ELECTRODES LIMITED · WINCOBANK SHEFFIELD · PHONE: ROTHERHAM 4836

Tick **No 67** on reply card for further details

Tick **No 68** on reply card for further details

SMALL-SCALE HIGH VACUUM FURNACE

All the facilities of an industrial furnace on a reduced scale !



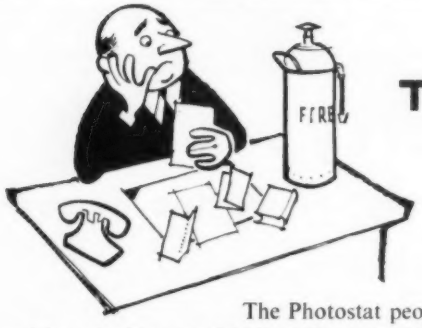
- Resistance heating, with either, or both, a furnace pot or a stationary radiation heater assembly.
- Suitable for sintering, melting and casting up to 1700°-1800°C.
- Brazing and heat-treatment up to 1500°C.
- Gas admission device for accelerated cooling.
- Self-contained with mechanical and high-speed vapour pumps, vacuum gauges, special valving and protection devices.
- Trolley mounted. Can be used, without furnace, as general-purpose high vacuum pumping station.
- A tilting furnace pot 5½" × 6" (140-152 mm) is controlled from the outside.

'SPEEDIVAC' ½-LB CAPACITY VACUUM FURNACE

For better vacuum service . . .

EDWARDS HIGH VACUUM LTD

MANOR ROYAL · CRAWLEY · SUSSEX CRAWLEY 1500 (10 LINES) EDCOHIVAC CRAWLEY

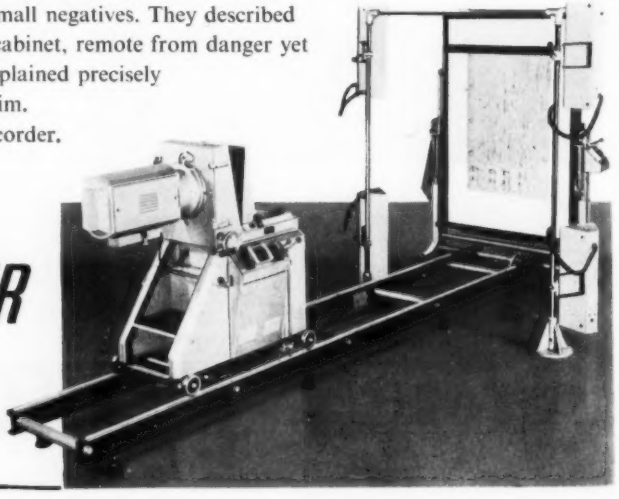


The Boss had a 'thing' about fire

He wondered, for example, what would happen if his company's huge files of plans and drawings were destroyed. They were irreplaceable—the chaos would be terrible! The poor man began to spend sleepless nights.

Then someone suggested that he should contact Photostat Ltd. The Photostat people told him about the 'Statfile' Recorder and how it photographically reduces drawings on to small negatives. They described how thousands of such drawings can be filed in a cabinet, remote from danger yet ready for easy reference or projection printing. They explained precisely how this remarkable drawing-office aid would help him.

The boss took their advice and installed a 'Statfile' Recorder. (He's sleeping much better now, thank you).



All over the world industrial companies are finding it pays to use a

STATFILE RECORDER

Model No. 3

PHOTOSTAT LTD., 1-4 Beech Street, London, E.C.1.
(Tel: METropolitan 0311-4)

'Statfile' is a registered trade-mark

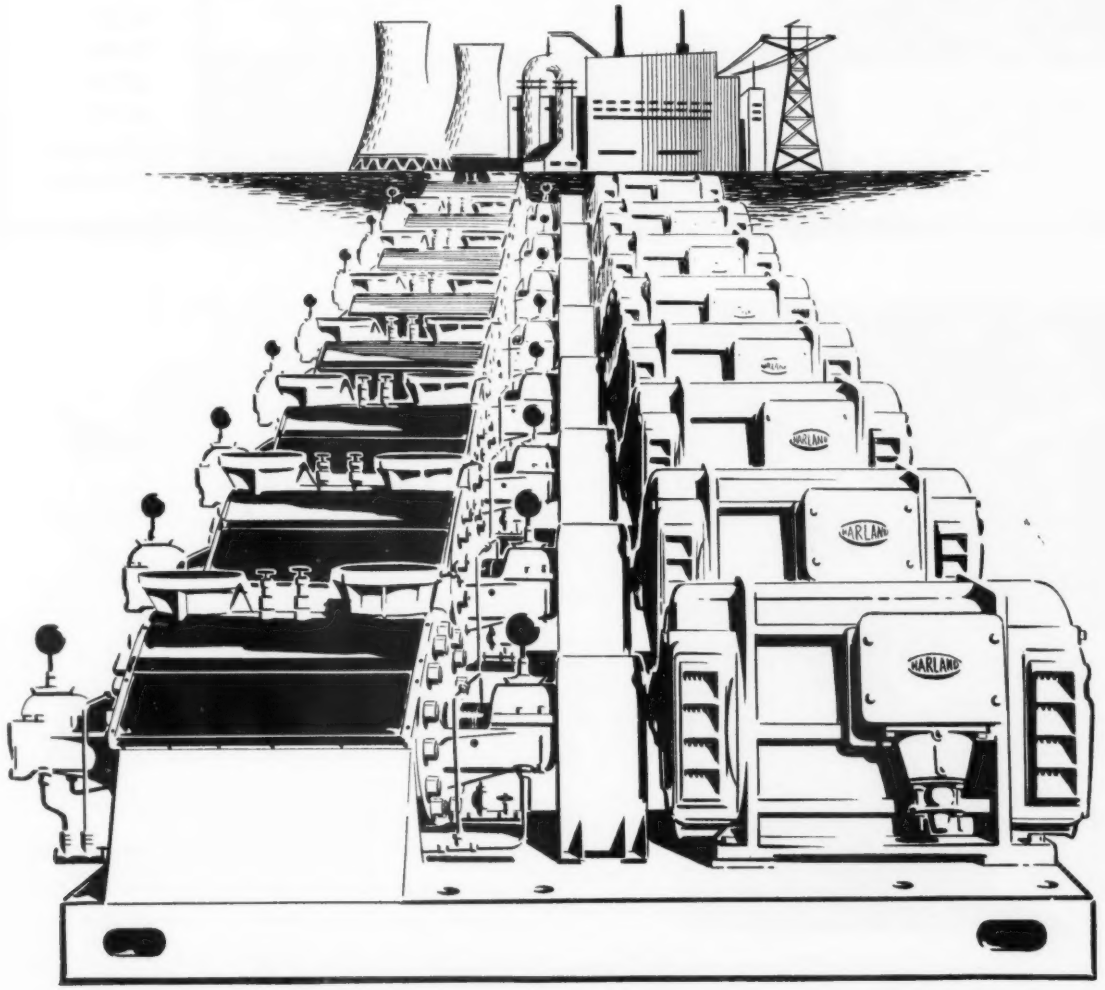
HARLAND

BOILER FEED PUMPS

at

Bradwell

On behalf of the Nuclear Power Plant Company, Messrs. C. A. Parsons have placed with Harland the contract for 10 groups of boiler feed pumps complete with motors for this major nuclear power station to be commissioned by the Central Electricity Authority within their first Nuclear Power programme.

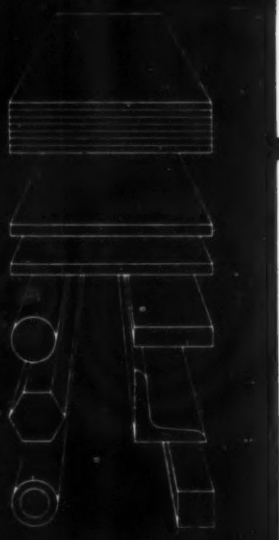


THE HARLAND ENGINEERING CO LTD ALLOA SCOTLAND

LONDON & EXPORT SALES OFFICES: HARLAND HOUSE 20 PARK STREET W1

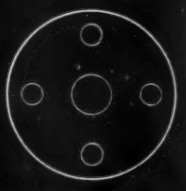
BRANCHES IN BRISTOL GLASGOW LEEDS NEWCASTLE NOTTINGHAM TIMPERLEY (Cheshire) WOLVERHAMPTON & Overseas

III



Prompt delivery from stock.

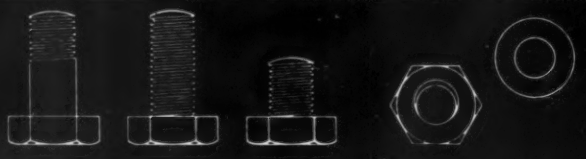
May we help you with your Stainless Steel requirements? A wide range of sizes in the vital specifications required by Nuclear and General Engineers is at your disposal.

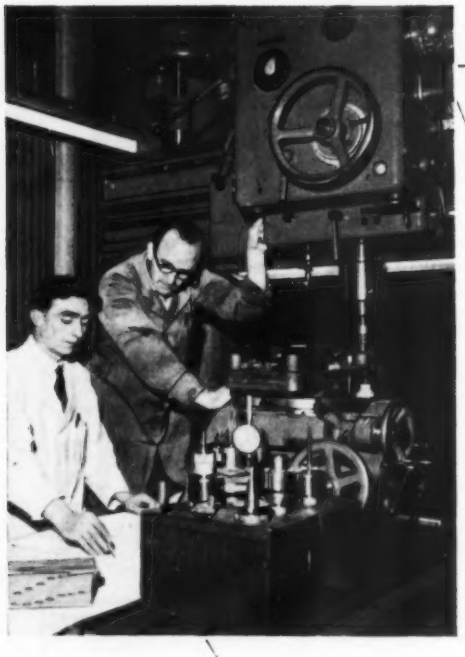


Stainless Steels

SHEETS
PLATES
BARS
TUBES
BOLTS
NUTS
FLANGES
FITTINGS

The Mulberry Company
Castle Wharf
Orchard Place
London, E. 14
Tel: EAST 4471





This way

for advanced engineering

Aeronautical engineering is an excellent school for nuclear engineering. That is the reason for this advertisement. Armstrong Whitworth have been concerned with aeronautical engineering right from its infancy. Our machine tools and their highly skilled operators are now tackling a wide variety of engineering problems. We might well be able to help you. Write or telephone to:

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LIMITED
BAGINTON, NR. COVENTRY. TOLLBAR 2261.

By courtesy of: U.K. Atomic Energy Authority
Central Electricity Generating Board
South of Scotland Electricity Board

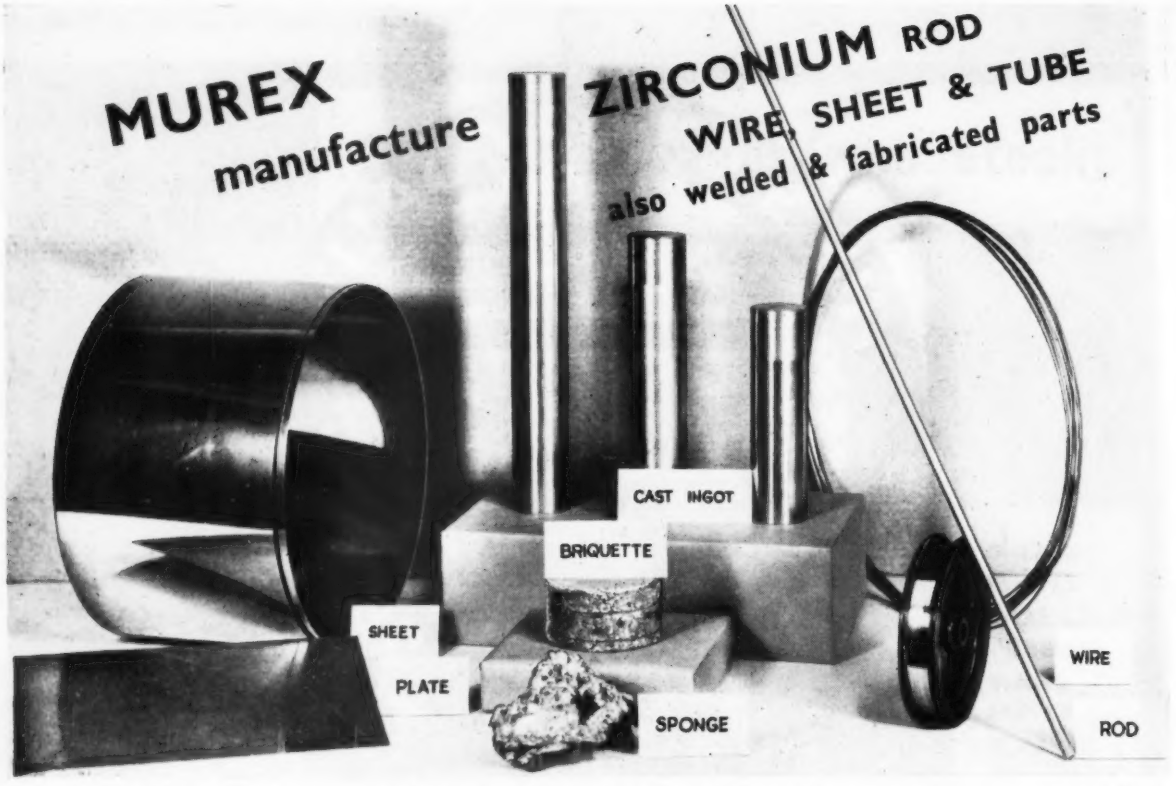
It has been our privilege to supply E.M.B. Control Gear for the following Atomic Energy Establishments

Site	Crane Maker	Duty	Type of Crane
Chapelcross	Babcock & Wilcox Ltd	Coffin Handling	E.O.T. with MICROsen
"	" "	Skip Handling	E.O.T. with control desk
"	" "	Basket Cranes	E.O.T.
"	Butters Bros & Co Ltd	Erection	Derricks
Dounreay	" " " "	"	"
"	" " " "	Maintenance	E.O.T. Cranes
"	Carruthers	Reactor House	Rotating E.O.T. inside sphere
"	Wharton	Maintenance	E.O.T.
Calder Hall	Clyde Crane	Coffin Handling	E.O.T. with MICROsen
Harwell	Wharton	" "	Rotating E.O.T.
Hinkley Point	Babcock & Wilcox Ltd	Almost all permanent cranes	Mainly E.O.T. with MICROsen
Berkeley	Butters Bros & Co Ltd	Erection	Monotower
"	Carruthers	Pilecap loading	Rigid Mast E.O.T. & MICROsen
Bradwell	Anderson-Grice	Erection	Derrick
Hunterston	Carruthers	Fabrication	40T Goliath

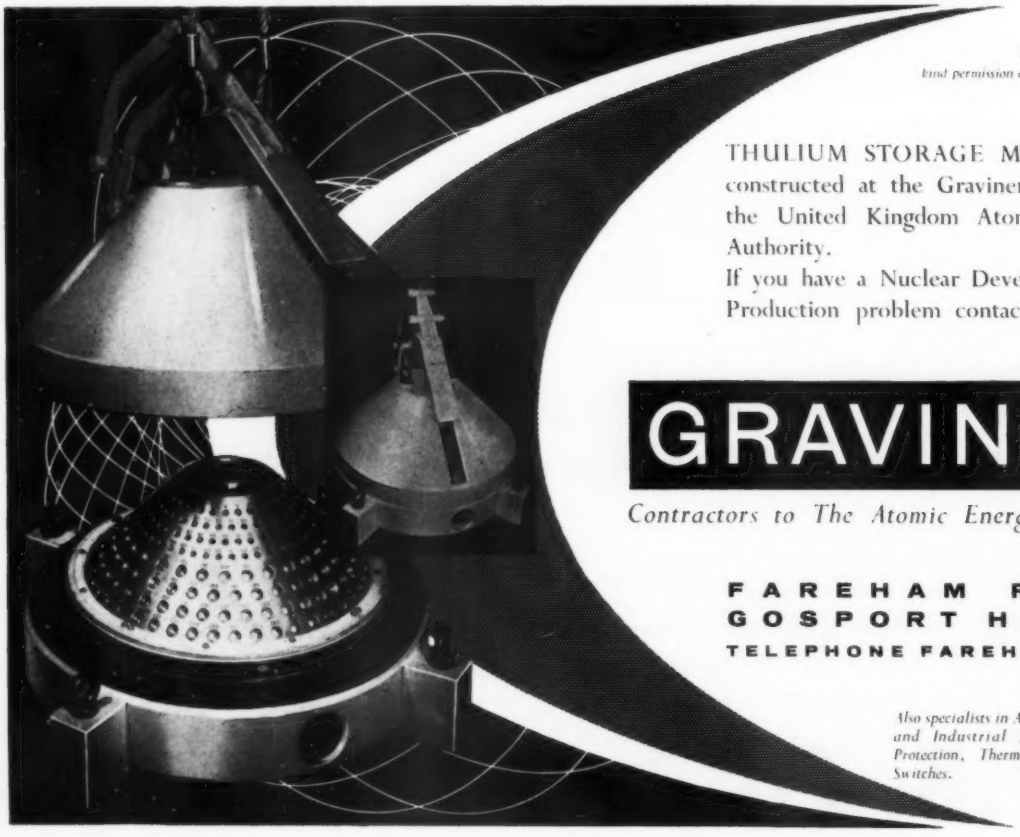
Where the conditions are exacting there you will find E.M.B. equipment giving excellent service.

E.M.B. Co. Ltd. WEST BROMWICH—ENGLAND

Tick **No 74** on reply card for further details



Write for full technical information :— **MUREX LIMITED** *(Powder Metallurgy Division)* RAINHAM . ESSEX
Telephone : Rainham, Essex 3322 Telex 28632 Telegrams : Murex, Rainham-Dagenham Telex
LONDON SALES OFFICE: CENTRAL HOUSE, UPPER WOBURN PLACE, W.C.1 *Telephone: EUSton 8265*



Photographs by kind permission of U.K.A.E.A.

THULIUM STORAGE MAGAZINE constructed at the Graviner works for the United Kingdom Atomic Energy Authority.
If you have a Nuclear Development or Production problem contact us today.

GRAVINER

Contractors to The Atomic Energy Authority

FAREHAM ROAD
GOSPORT HANTS
TELEPHONE FAREHAM 2511

Also specialists in Airborne, Diesel Engine and Industrial Fire and Explosion Protection, Thermostats and Overheat Switches.

Tick **No 77** on reply card for further details

'HYDROBORD'

for

NEUTRON SHIELDING

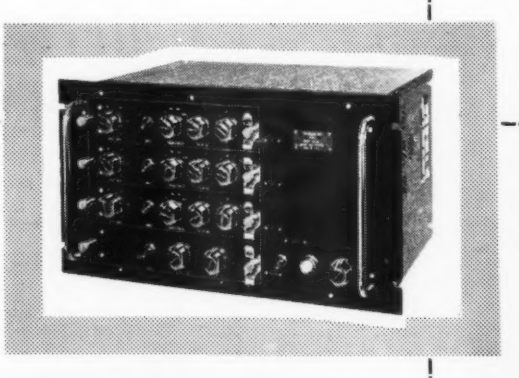
HYDROBORD provides insulation against Fast and Thermal Neutrons or combinations of both.

William Mallinson and Sons Ltd.

130 HACKNEY ROAD · LONDON · E.2

Telephone: Shoreditch 7654

Telegrams: 'Almoner', London



coincidence unit type 1036c

The new Dynatron Coincidence Unit Type 1036C contains a 3 channel coincidence circuit which may be used in any one of the following arrangements :

I Channels 1 and 2 in coincidence.
II Channels 1 and 2 in coincidence, the output being in coincidence with channel 3.
III Channels 1 and 2 in coincidence, the output being in anti-coincidence with channel 3.
IV Channel 3 in coincidence with channels 1 or 2.
V Channel 3 in anti-coincidence with channels 1 or 2.

The three input channels and the coincidence mixer are sub-units which are removable from the front panel. The complete unit is constructed on a 10½ inch Post Office rack panel.

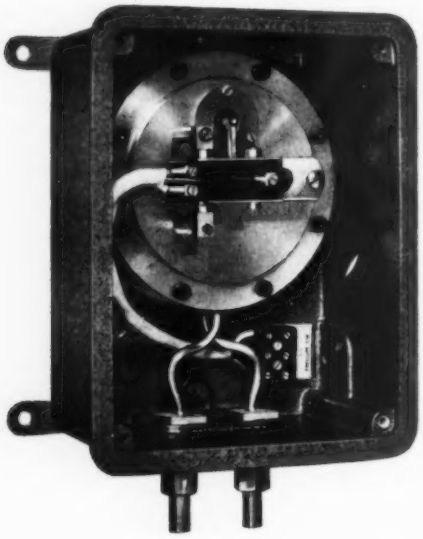
DYNATRON

NUCLEONIC & ELECTRONIC DEPT.
Dynatron Radio Ltd., Maidenhead, Berkshire
Telephone: Maidenhead 5151/2/3/4/5

Scalers · Pulse Generators · Pulse Analysers · Power Units · Probe Units · Pulse Amplifiers · Instrument Racks

Tick **No 78** on reply card for further details

Tick **No 79** on reply card for further details



DIFFERENTIAL PRESSURE SWITCH

Suitable for control on liquids, steam, gases, etc., this instrument is available in ranges from 1 p.s.i. for maximum static pressures up to 150 p.s.i., with snap action or slow moving contacts, as required.

Write for full details and specifications to :

In association with Stow and Partners Ltd.

K.D.G. INSTRUMENTS LTD.

MANOR ROYAL, CRAWLEY, SUSSEX. Crawley 25151

London Showrooms, Service and Sales : 100 FLEET STREET, E.C.4. Tel : FLEet Street 5354/5

CRAWLEY KDG LONDON

ATOMIC ENGINEERING ACHIEVEMENTS

Opposite, a liquid metal heat transfer loop set under a 550°C. NaK test.

(designed and constructed under the supervision of the EDF's Study & Research Section).

Other atomic engineering achievements :

—GACHOT Bellows Valves

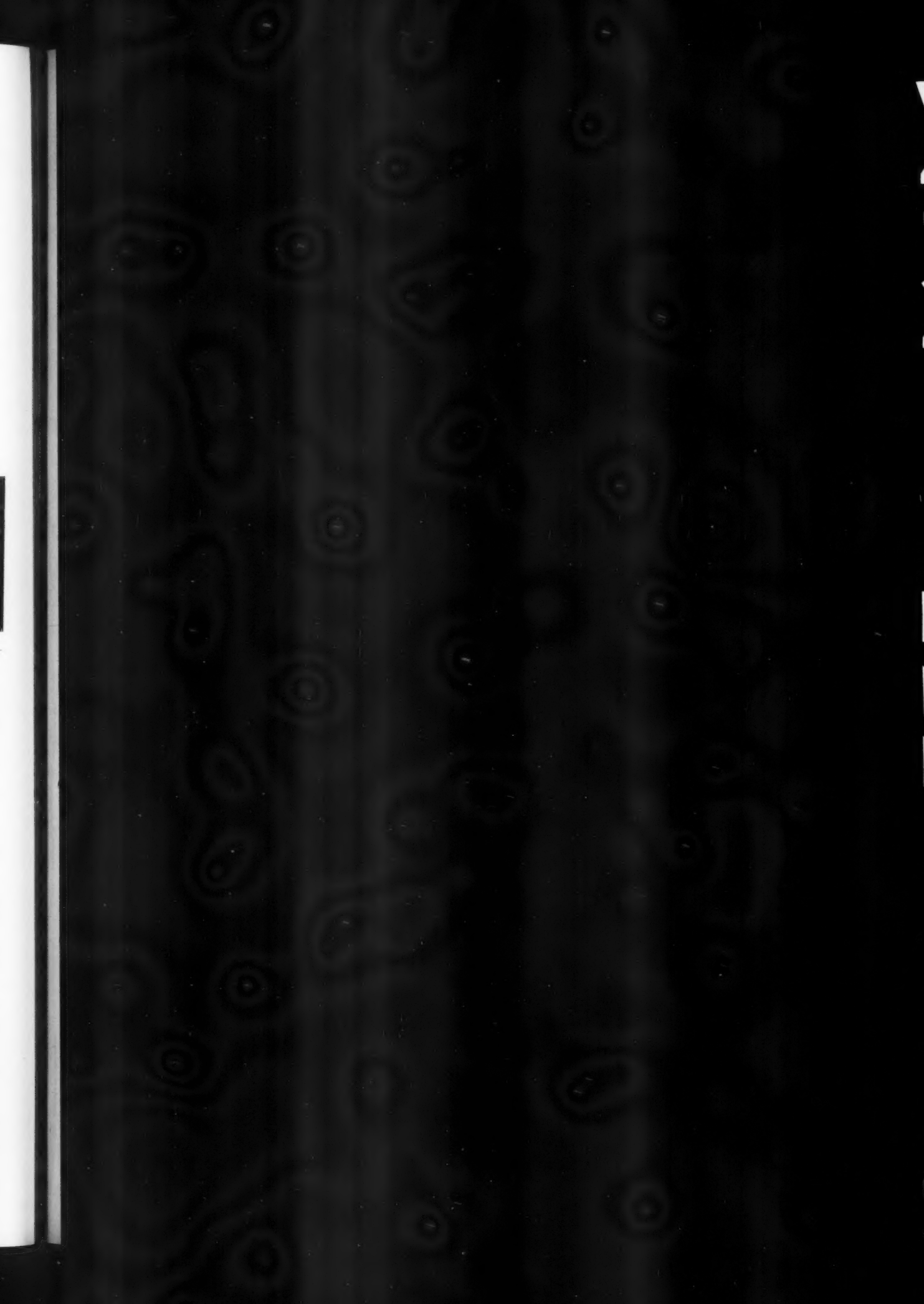
—Valves fitted with electro-magnetic drive and special valves for the detecting of burst fuel slugs.

—Valves and other devices with magnetic couplings (permanent magnet).

TECHNIQUES NUCLÉAIRES

SOCIÉTÉ D'ÉTUDES ET DE RÉALISATIONS

82, RUE DE MONTIGNY ARGENTEUIL (S.&O.) FRANCE. Tél. ARGENTEUIL 19-93



SERVICE DE RENSEIGNEMENTS POUR NOS LECTEURS

Il est souvent difficile au client publicitaire d'indiquer dans un espace restreint tous les détails de ses produits. Dans le cas où vous désireriez de plus amples renseignements à ce sujet, veuillez pointer le numéro approprié sur la carte ci-contre et envoyer cette dernière à NUCLEAR POWER.

AUSKUNFTSDIENST FÜR LESER

Es ist oft schwierig für Inserenten alle technischen Einzelheiten über ihre Produkte in einem begrenzten Platz zu bringen. Sollten Sie noch weitere Auskünfte wünschen, streichen Sie einfach die bestimmten Nummern auf der nebenstehenden Karte an, und senden Sie sie an NUCLEAR POWER.

SERVIZIO D'INFORMAZIONI PER I NOSTRI LETTORI

E' talvolta difficile all'inserzionista di indicare in uno spazio ristretto tutti i particolari dei suoi prodotti. Qualora desideraste ricevere più ampie informazioni a questo riguardo, favorite segnare il numero appropriato sul cartellino qui accanto ed inviare quest'ultimo a NUCLEAR POWER.

SERVICIO DE INFORMACIÓN PARA EL LECTOR

Se hace a menudo difícil para los anunciantes dar en un espacio limitado todos los detalles técnicos sobre sus productos. Si desea ulterior información, marque los números apropiados en la tarjeta opuesta y mándela a NUCLEAR POWER.

Информация для читателей

Часто бывает трудно рекламирующим лицам давать все технические подробности своей продукции в рекламе. Если Вам понадобятся добавочные сведения, то просто отметьте соответствующие номера на карточке на противоположной стороне и отправьте в NUCLEAR POWER.

讀者詢問服務

在廣告上以有限的地方來解釋一些專门技術 及它們的効果 的確是有受限制的困难尚請原諒如遠一些詳細的情形就請將对貴的表格 取一張下來將阁下有疑問的項目 问笔勾一下郵寄給予能工程師即可.

読者サービス

廣告紙面の関係上製品の技術的細目は掲載しきれません ので詳しくは貴のカードの適當なナンバーに印をつけて原子力 局宛御申しこしてくださればお答へします.

Nuclear Power
REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

READER INFORMATION SERVICE **February 1959**

ADVERTISEMENTS

1	24	47	70	93	116	139	162
2	25	48	71	94	117	140	163
3	26	49	72	95	118	141	164
4	27	50	73	96	119	142	165
5	28	51	74	97	120	143	166
6	29	52	75	98	121	144	167
7	30	53	76	99	122	145	168
8	31	54	77	100	123	146	169
9	32	55	78	101	124	147	170
10	33	56	79	102	125	148	171
11	34	57	80	103	126	149	172
12	35	58	81	104	127	150	173
13	36	59	82	105	128	151	174
14	37	60	83	106	129	152	175
15	38	61	84	107	130	153	176
16	39	62	85	108	131	154	177
17	40	63	86	109	132	155	178
18	41	64	87	110	133	156	179
19	42	65	88	111	134	157	180
20	43	66	89	112	135	158	181
21	44	67	90	113	136	159	182
22	45	68	91	114	137	160	183
23	46	69	92	115	138	161	184

NEW PRODUCTS & TECH. LITERATURE

185	190	195	200	205	210	215	220
186	191	196	201	206	211	216	221
187	192	197	202	207	212	217	222
188	193	198	203	208	213	218	223
189	194	199	204	209	214	219	224

BOOKS

225	227	229	231	233	235	237	239
226	228	230	232	234	236	238	240

If you would like further information about any advertisement or editorial item, simply tick the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME _____

NAME OF BUSINESS _____

ADDRESS _____

_____

POSITION HELD _____

NATURE OF BUSINESS _____

_____

Nuclear Power
REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

READER INFORMATION SERVICE **February 1959**

ADVERTISEMENTS

1	24	47	70	93	116	139	162
2	25	48	71	94	117	140	163
3	26	49	72	95	118	141	164
4	27	50	73	96	119	142	165
5	28	51	74	97	120	143	166
6	29	52	75	98	121	144	167
7	30	53	76	99	122	145	168
8	31	54	77	100	123	146	169
9	32	55	78	101	124	147	170
10	33	56	79	102	125	148	171
11	34	57	80	103	126	149	172
12	35	58	81	104	127	150	173
13	36	59	82	105	128	151	174
14	37	60	83	106	129	152	175
15	38	61	84	107	130	153	176
16	39	62	85	108	131	154	177
17	40	63	86	109	132	155	178
18	41	64	87	110	133	156	179
19	42	65	88	111	134	157	180
20	43	66	89	112	135	158	181
21	44	67	90	113	136	159	182
22	45	68	91	114	137	160	183
23	46	69	92	115	138	161	184

NEW PRODUCTS & TECH. LITERATURE

185	190	195	200	205	210	215	220
186	191	196	201	206	211	216	221
187	192	197	202	207	212	217	222
188	193	198	203	208	213	218	223
189	194	199	204	209	214	219	224

BOOKS

225	227	229	231	233	235	237	239
226	228	230	232	234	236	238	240

If you would like further information about any advertisement or editorial item, simply tick the appropriate numbers on this card and mail to NUCLEAR POWER.

NAME _____

NAME OF BUSINESS _____

ADDRESS _____

_____

POSITION HELD _____

NATURE OF BUSINESS _____

_____

SUBSCRIPTION CARD **Nuclear Power**
REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

February 1959

YES!

I want my own PERSONAL copy!

Please send me NUCLEAR POWER for 12 months/until countermanded:

U.K. **£2. 2s. 0d.**

U.S.A. and Canada **$8.00** + **50c.** postage

Other countries **£3. 3s. 0d.**

starting with the _____ issue

☐ Subscription enclosed

☐ Invoice me later

NAME _____

SEND TO MY HOME/BUSINESS ADDRESS _____

_____

_____

Postage will be paid by uclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by uclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

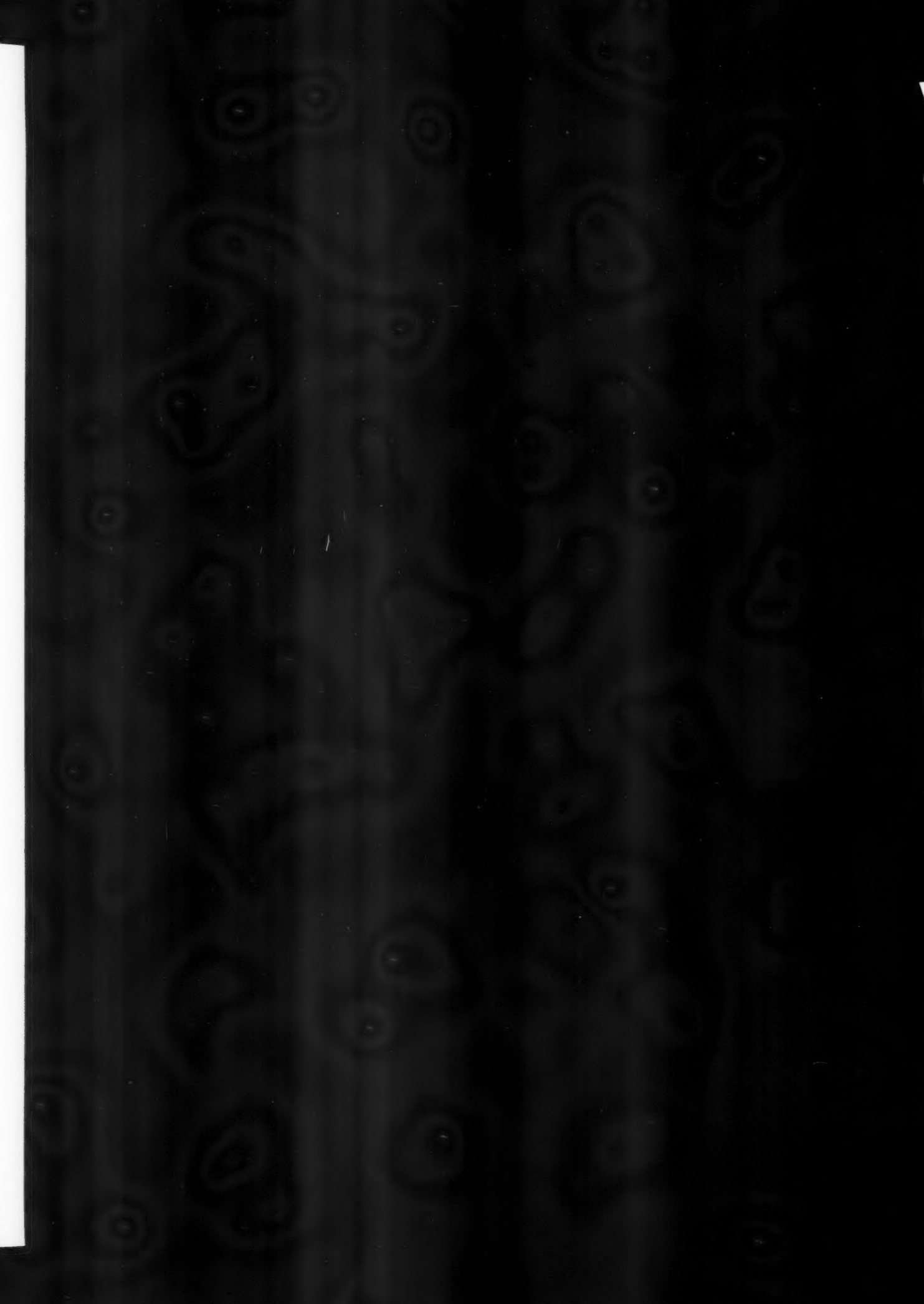
Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England

Postage will be paid by Nuclear Power

No Postage stamp necessary if posted in Great Britain or Northern Ireland

Business Reply Folder Licence WD 1823

Nuclear Power,
Rowse Muir Publications Ltd,
3 Percy Street,
London, W1
England



BINDING Nuclear Power

REACTORS · MATERIALS · INSTRUMENTATION · PROCESSES · IRRADIATION

You often want to refer to NUCLEAR POWER . . .

. . . these Easibinders will hold up to 6 copies of NUCLEAR POWER (8 of Vol. 1) for quick and easy reference

12/6 each plus 1/6 postage and packing

TO ROWSE MUIR PUBLICATIONS LTD., 3 PERCY STREET, LONDON, W1

Please supply _____ Easibinders for NUCLEAR POWER (Vol. 1 / other Vols.)

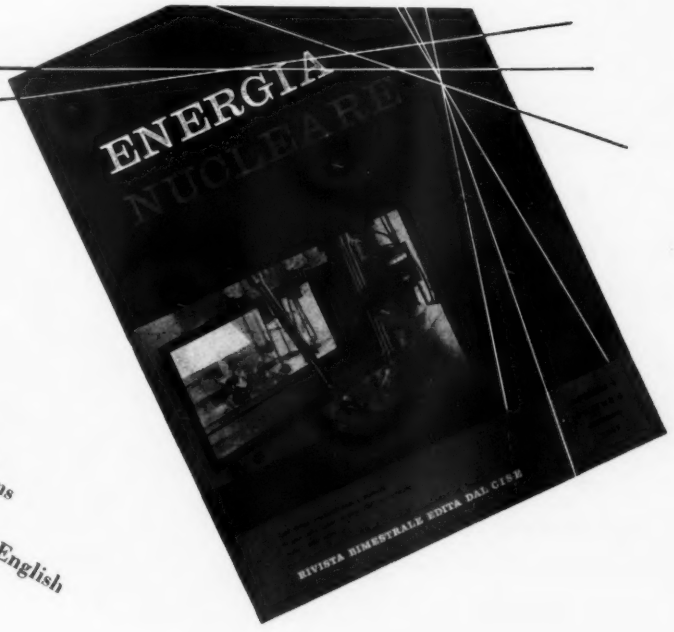
NAME _____

ADDRESS _____

_____

PRICE 12/6 BINDER, I ENCLOSE _____

Publishers: CISE
Centro Informazioni
Studi Esperienze
Milano, via Serbelloni 1



ENERGIA NUCLEARE
is the Italian magazine dealing with the theoretical and practical problems in the atomic energy field.
Original research papers are published in English
Subscription rate for 1958:
12 issues 1.6000 (£3.10.0)

Sole Agents for Great Britain:

Subscriptions: Nuclear Power, Rowse Muir Publications Ltd. 3 Percy St., London, W1

Advertising: Butlers' Advertising Service Ltd. 22 St. Giles High St., London, WC2

Tick No 141 on reply card for further details

Simplifix pipe couplings are interchangeable

For assembling pipe line systems quickly and easily, use standardised Simplifix couplings. Made to B.S.S. 2051 Part I, their high standard of dimensional accuracy ensures that all fittings are interchangeable. They can be used on almost any kind of tubing, including those with very thin walls, and are available in the widest possible variations of standard and non-standard fittings. In brief you are most likely to find *your* requirements in the Simplifix range. Our illustrated catalogue gladly sent on request.

SIMPLIFIX

Regd. Trade Mark

SIMPLIFIX COUPLINGS LTD
HARGRAVE ROAD, MAIDENHEAD, BERKS
TEL: MAIDENHEAD 5100 (10 lines)

MACHINING OF NUCLEAR GRAPHITE

•

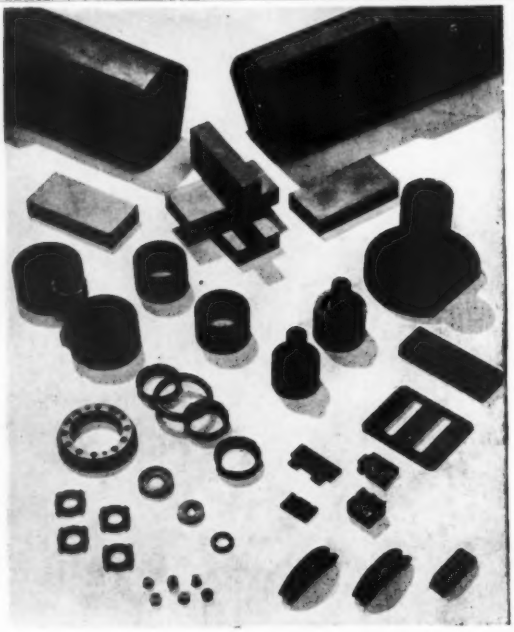
FULLY EQUIPPED MACHINE SHOP

•

SPECIAL MACHINE PARTS

•

SECURITY



H.M. GOVERNMENT DEPARTMENTS

•

NUCLEAR ENGINEERING FIRMS

•

RESEARCH LABORATORIES

•

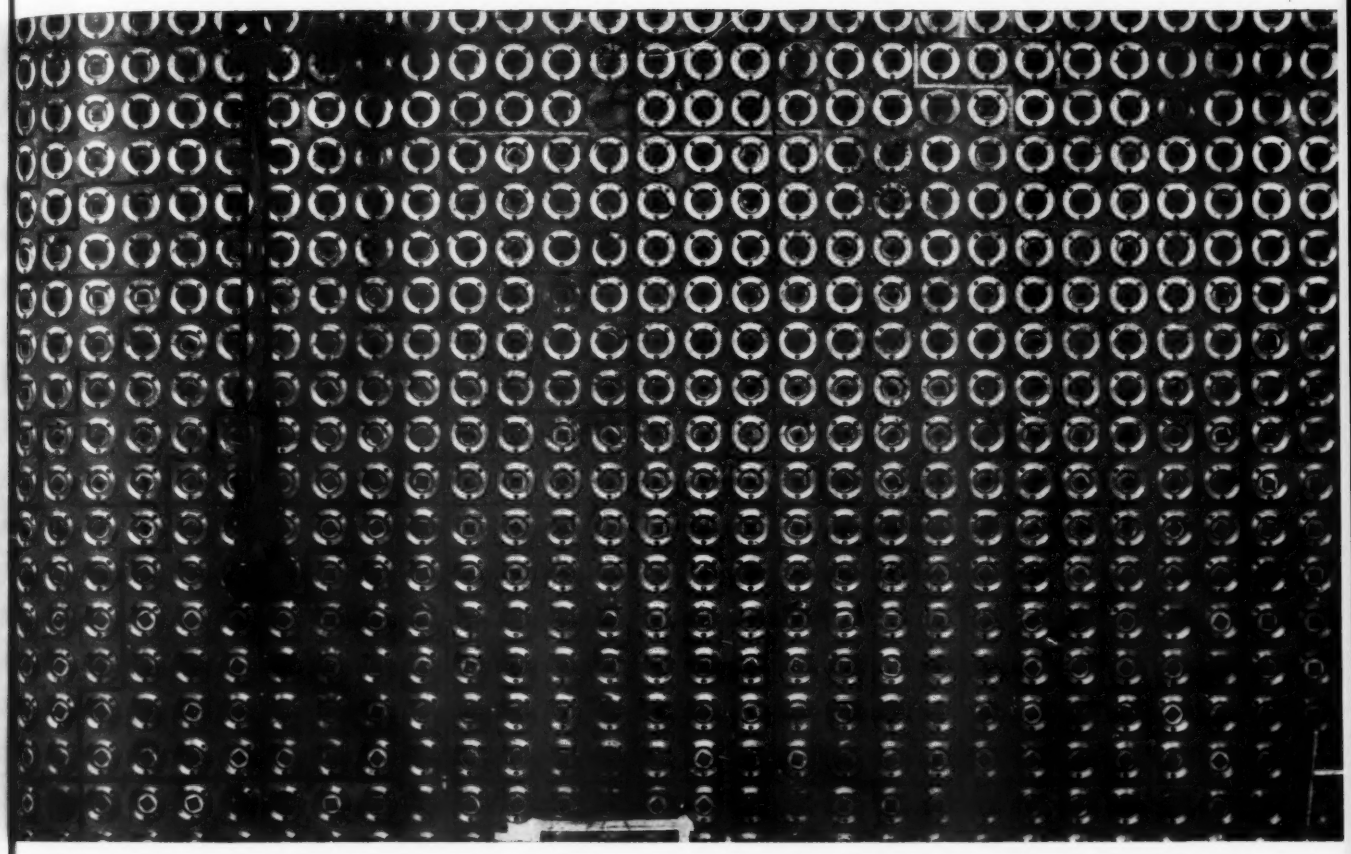
ELECTRICAL INDUSTRY

NOBRAC CARBON LIMITED

Commerce Way, Lancing, Sussex Telephone: Lancing 2053 (3 lines)

Tick No 142 on reply card for further details

A BREAKDOWN HERE COULD COST A FORTUNE



What is the most important piece of machinery in your factory ?

What would be the cost per day to your business if it were to break down ?

It is now possible to cover the loss of profits resulting from such a breakdown as well as the cost of repairing the machine itself.

Policies can be issued to meet the particular requirements of any business.

In this way you can be indemnified against the serious interruptions to your business which can be caused by machinery breakdown.

Should you feel in need of the protection of this new form of insurance we can send an engineer to advise you and inspect your plant.

Write to **D. H. EVERS,** *Industrial insurance consultant*
ONE ARUNDEL COURT JUBILEE PLACE LONDON S.W.3

Tick **No 144** on reply card for further details

for the widest range

LONDEX

relays

LONDEX for Relays and Contactors of every type, for every purpose: miniature, super-sensitive, heavy current, coaxial, electronic, time delay, differential, etc., etc.

LONDEX for Reliability at low cost.

LONDEX for the latest in relay design.

LONDEX for process timers, electronic counters, earth leakage and photo-electric equipment, level controls and pressure switches.

Write for our Data Book No. 144/N.P. containing details of the full range of Londex products.

STAND G3 ELECTRICAL ENGINEERS EXHIBITION

LONDEX LTD.

ANERLEY WORKS, LONDON, SE20
Tel: SYDenham 3111

General Service Contactor Type LB
For AC or DC operation.

NUCLEAR REACTOR PHYSICS

an elementary course

by JAMES F. HILL B.Sc. principal, Reactor School A.E.R.E. Harwell

In response to widespread demands, we have reprinted the course in basic reactor physics which was specially written for NUCLEAR POWER and published in serial form during 1956 and 1957. The monograph has been revised by the author and forms an excellent introduction. (64 pp. in stiff boards.) Price: UK, 30s + 1s 3d Abroad $5 + 20c or equivalent

TO: ROWSE MUIR PUBLICATIONS LTD
3 PERCY ST, LONDON W 1.

Please send me____ copy/s of Hill's REACTOR PHYSICS

☐ I enclose _____

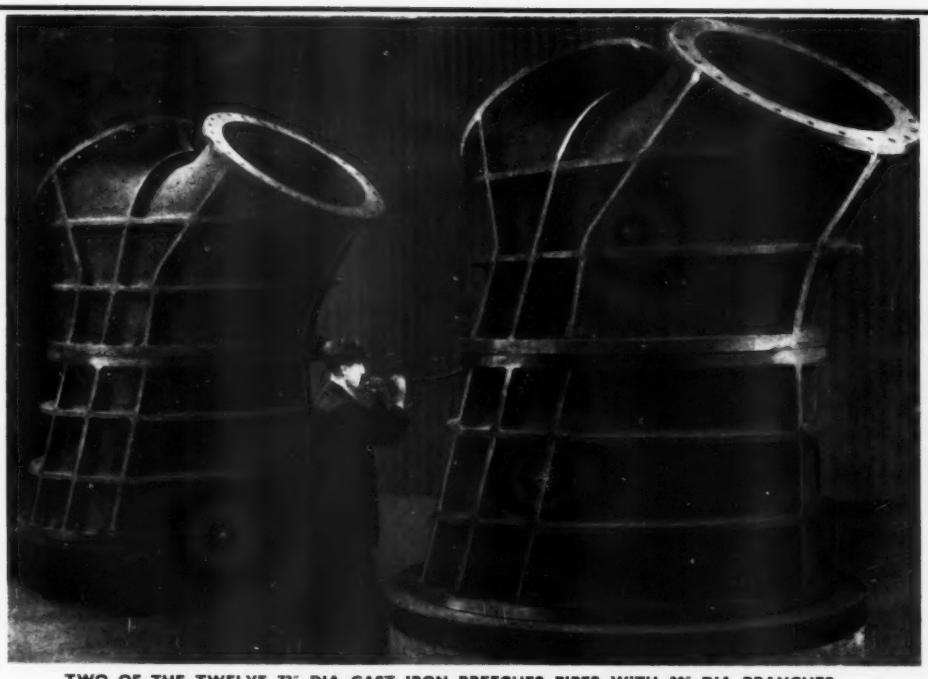
☐ Please invoice me

NAME _____

ADDRESS _____

Tick **No 145** on reply card for further details

Cast Iron Work of all Descriptions and to Special Metal Mixtures



Please Send US Your Enquiries

TWO OF THE TWELVE 72" DIA CAST IRON BREECHES PIPES WITH 39" DIA BRANCHES. WEIGHT APPROXIMATELY 7 TONS EACH. PART OF A RECENT ORDER IN CONNECTION WITH A LARGE STEAM CONDENSING PLANT.

C. & W. WALKER LTD.

Telephone: - LILLESHALL - SHROPSHIRE 371 (4 LINES)

MIDLAND IRONWORKS . DONNINGTON . NR. WELLINGTON · SHROPSHIRE

HEAVY DUTY
SPANNERS

Precision Hand Tools are of paramount importance to the Engineering Industry. King Dick hand tools are precision made under carefully controlled conditions, and set a superlative standard in quality and design. From the largest Constructional Engineering Tools to the smallest B.A. Socket Set, King Dick inspection routines ensure the correct combination of selected steels, perfect balance and precision.

Send for illustrated catalogue giving complete range of King Dick Hand Tools.

BINGDON
KING DICK

PRECISION HAND TOOLS

ABINGDON KING DICK LTD., Abingdon Works, Tyseley, Birmingham 11, England

R.E. 216

for CATHODIC PROTECTION

or WELDING INSPECTION

call in MAPEL

MAPEL

METAL & PIPELINE ENDURANCE LTD.,

Artillery Mansions, Victoria Street, London, S.W.1.
Tel: ABBey 6056 'Grams: Metaldure, Sowest, London

Divisional offices at Woolmer Green, Herts; also at Newcastle upon Tyne and Glasgow

AGENTS THROUGHOUT THE WORLD

Man and Method

The result of this craftsman's work will be an interior surface, smooth as silk—without blemish, and completely safe for the bulk transportation of edible liquids.
He is skilled and proud of it and, like his colleagues in other crafts, he meets the exacting demand set by Darham in the construction of road tanks, transportable tanks and storage tanks for customers in countless industries at home and overseas.

DARHAM TECHNICAL ADVISORY SERVICE is on call to you. If you would have tanks that are accepted as a standard by which others are judged you will seek the advice of Darham.

DARHAM build fine tanks in Mild Steel (suitably lined if necessary), Stainless Steel and Aluminium.

Darham

DARHAM INDUSTRIES (LONDON) LIMITED
13 Victoria Street, London, S.W.1.
ABBey 2231 (3 lines)
WORKS: BASILDON ESSEX AND DURHAM CITY

ENGINEERS!!

buy from

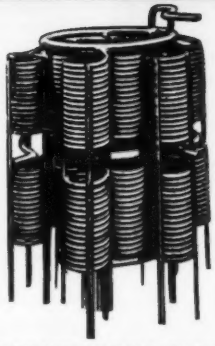
KIRKS-

FORGED STEEL FLANGES

TO BRITISH AND AMERICAN STANDARDS

STAINLESS STEEL STUB NIPPLES

FABRICATED PIPEWORK IN STEEL, STAINLESS STEEL AND COPPER



K

THE HEART OF RELIABILITY

MALLEABLE TUBE FITTINGS TO BRITISH STANDARDS

...and you **BUY BRITISH!**

KIRK

& CO (TUBES) LTD

74-82 PARADISE ST., LONDON, S.E.16

BERMONDSEY 3156/7/8

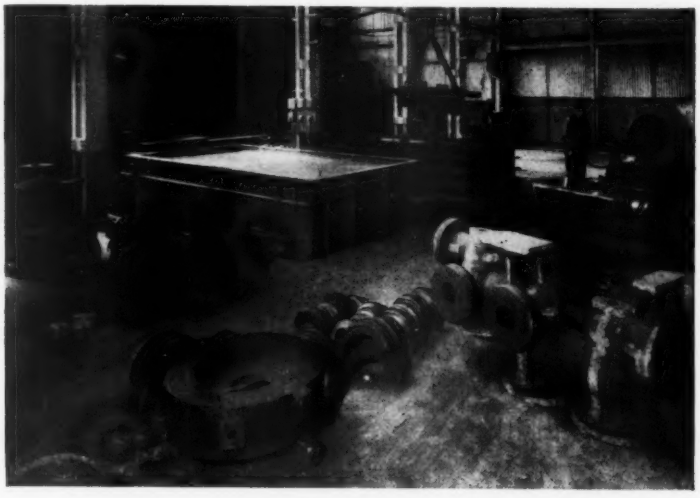
WALSALL · MANCHESTER · PONTYCLUN

– as British as the Flag

ATLAS

STEEL CASTINGS

For Internal Pressure Work



Turbine Castings, Steam Chests, Valves, etc. in carbon and alloy steels up to 9 tons weight and to any specification.

ON ADMIRALTY, WAR OFFICE, LLOYD'S and other LISTS

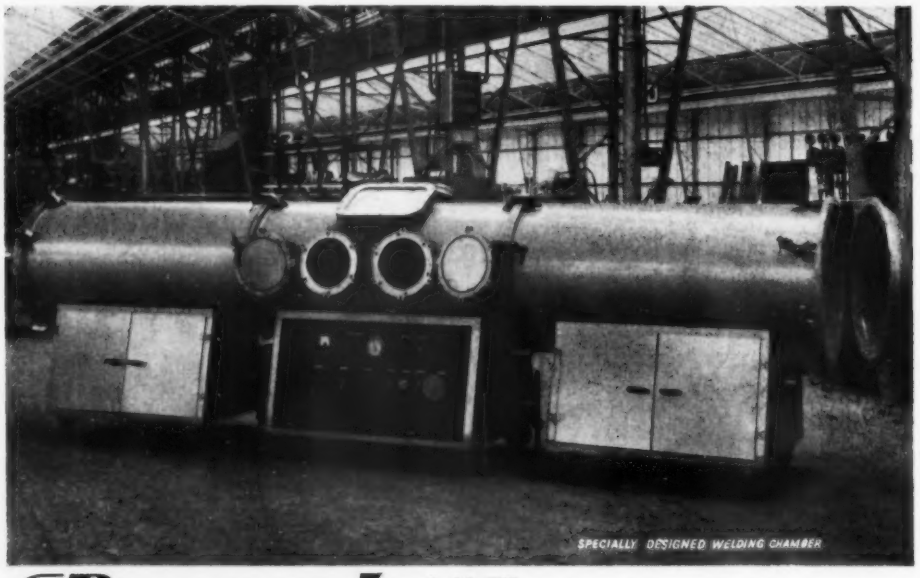
THE ATLAS STEEL FOUNDRY & ENGINEERING COMPANY, LIMITED

ATLAS STEEL WORKS: ARMADALE, WEST LOTHIAN, SCOTLAND

Telegrams: "ATLAS ARMADALE WEST LOTHIAN" Telephone No.: Armadale 323

Tick **No 152** on reply card for further details

fabricators in the rarer metals....



TITANIUM
ZIRCONIUM
HAFNIUM
MAGNESIUM ALLOYS
NIOBIUM
ETC.

ALSO
NICKEL
ALLOY STEELS

AND
STAINLESS STEELS

EST. 1844

PHONE : 24228
28264 (5 LINES)
AND
ECKINGTON 551

J.R. **Bramah** & CO. LTD. (OF) **Sheffield**

DEVONSHIRE STREET · SHEFFIELD 3

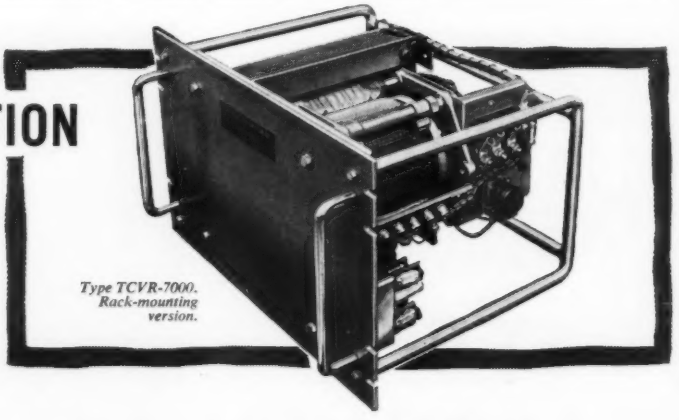
40 VOLTS/SEC AUTOMATIC CORRECTION

—with the type TCVR voltage regulator

The TCVR is a servomechanical automatic voltage regulator having the very high speed of correction of FORTY VOLTS PER SECOND. It provides an *undistorted* output, maintained constant within very close limits (normally ±0.5%) from no-load to full-load, for wide variations in frequency and power factor.

A wide range of models from 1.6 to 12 kVA single-phase, and 4.8 to 36 kVA three-phase, is available, to standard or tropical specification, in cabinets or for rack-mounting. Models are also available in which the output voltage is continuously adjustable over a wide range by means of a panel control. Regulators can be supplied to Services' specification, and special models can be designed to order.

For high-speed, accurate stabilisation *without distortion*—**specify TCVR.**



Type TCVR-7000. Rack-mounting version.

Claude Lyons Ltd.

Other products of Claude Lyons Ltd. Stabiliser Division

BMVR: Motor-driven laboratory and industrial regulators ranging from 1·6 to 29 kVA single-phase, and 4·8 to 87 kVA three-phase. Constancy of output normally ± 0·5%, from no-load to full-load. No distortion. Speed of correction 1 Volt/Sec. A great variety of models, standard, tropical and militarised, for all applications.

BAVR: Electronic stabilisers of very high accuracy, and very rapid response, with no moving parts. Input range : − 10% to + 5%, output constancy ± 0.15%. Three sizes : 200, 500 & 1000 VA. Exceptionally useful for control of chemical processes, heating, lighting, etc.

ASR: Automatic step regulators, small, inexpensive, and with sinusoidal output waveform. Two sizes : 1·15 kVA and 2·3 kVA. Input range − 10% to + 5%; output constancy, ±2½%.

ATC: Automatic Tap-Changing Transformers — a development of ASR. Two sizes : 575 VA and 1150 VA. Input range − 20% to + 10% : output constancy, ± 5%. Provide adequate stabilisation for many types of apparatus, at low cost. Also useful as pre-regulators, e.g. in conjunction with BAVR.

We shall be pleased to send you full details of our entire range.

Stabiliser Division **VALLEY WORKS · HODDESDON · HERTS · TELEPHONE HODdesdon 3007-8-9**

CL/47/E2B

HEATING MANTLES

for the laboratory and for pilot plant

Electrothermal offers the largest range of heating mantles accommodating any size of glass, silica, porcelain or metal vessel.

CONSTRUCTIONS AVAILABLE ARE:—

- SERIES M **standard aluminium housed mantles.**
- SERIES MV **"Multimantle," an aluminium housed multi-purpose mantle for use with a range of vessels.**
- SERIES MY **aluminium housed mantles of simplified design.**
- SERIES MJ **all-flexible mantles with the ingenious neck opening.**

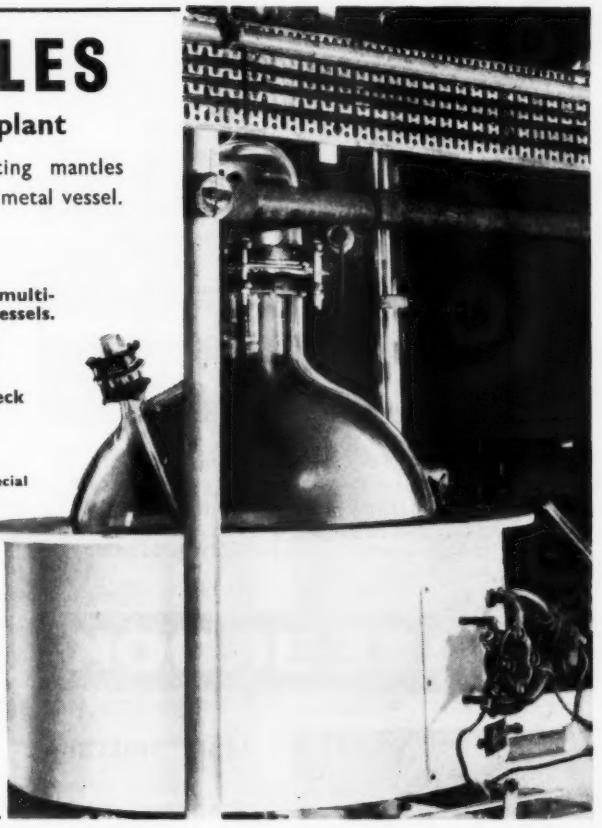
Available from all Laboratory Supply Houses

Apart from the standard ranges, mantles can be built for special requirements such as for operation:-

● **in flameproof areas** ● **with inert gas** ● **at high loadings**

Illustration shows 100 and 200 litre Series M mantles with Buxton certified connections in use at the Distillers Co. Ltd.

PLEASE REQUEST LEAFLET No. NW307/4



Electrothermal

ELECTROTHERMAL ENGINEERING LTD.
270 Neville Road, London, E.7. *Tel GRA 9911*

NON FERROUS METALS

For the most comprehensive stock available

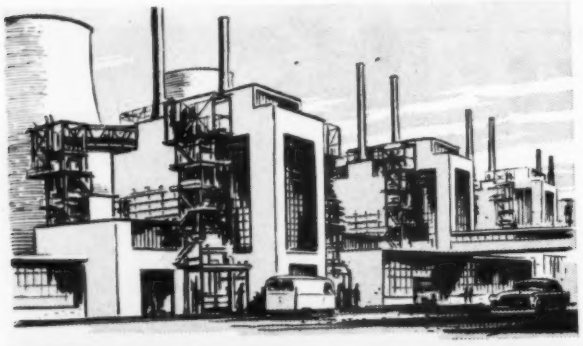
BRASS, COPPER, PHOSPHOR BRONZE, GUN METAL, NICKEL SILVER
ALUMINIUM, DURALUMIN, TIN PLATES, ZINC SHEETS
TEE RODS, TUBES, STRIPS, SHEETS, BLANKS, ANGLES, CHANNELS
RIVETS, SCREWS, NUTS, WASHERS, GAUZE, SOLDER
PERFORATED SHEETS, STUDDING

J. SMITH & SONS (CLERKENWELL) LTD.
42/54, ST. JOHN'S SQUARE, CLERKENWELL, LONDON, E.C.1

phone: CLE 1277 (14 lines)
Screw Dept: CLE 0925

Tick **No 155** on reply card for further details

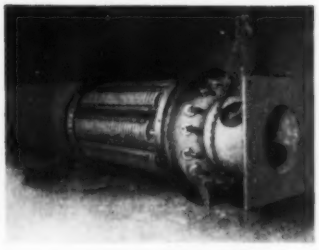
Tick **No 156** on reply card for further details



To be sure...

Since 1750 GRAZEBROOK have been in the forefront for specialised heavy engineering productions. Today the Company is equipped to meet the most exacting demands of modern industry and we invite you to contact us with YOUR particular production problems

GRAZEBROOK



LEAD SHIELDING

REACTOR TANKS

PRESSURE VESSELS
(STAINLESS STEEL AND ALUMINIUM)

CHEMICAL VESSELS • CALANDRIAS

can make it!

HEAVY MACHINING FACILITIES

Plant and machinery, to to customers design, manufactured and installed for the Steel, Rubber and Plastic industries.

•

GREY IRON CASTINGS UP TO 20 TONS

M. & W. GRAZEBROOK LTD

HEAVY ENGINEERS & IRON FOUNDERS

DUDLEY · WORCS

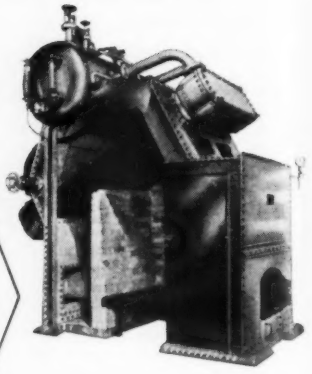
Telephone: DUDLEY 2431-3 *Telegrams: Grazebrook, Dudley*

Tick **No 157** on reply card for further details

When Replacing Obsolete

STEAM BOILERS

INSTAL THE FRASER WATER-TUBE BOILER



Unsurpassed for efficiency and versatility, the Fraser Boiler has the distinctive merit that it incorporates a large brick-lined smoke consuming combustion chamber, thus complying with the requirements of the Clean Air Act.

Write for illustrated literature

FRASER & FRASER LTD

Bromley-by-Bow, London, E.3.

Telephone ADVance 3266 (4 lines) Telegrams: Pressure, Easphone, London.

Tick **No 158** on reply card for further details

SOUTHBOROUGH

DEVELOPMENT, PRODUCTION AND PRECISION ENGINEERS

Specialists in sheet metal work and prefabrication to the Nuclear field

in

STAINLESS STEEL

MAGNESIUM

NIMONIC ALLOYS

etc.

Argon-Arc, Gas and Electric Welding

A.I.D. and A.R.B. approved

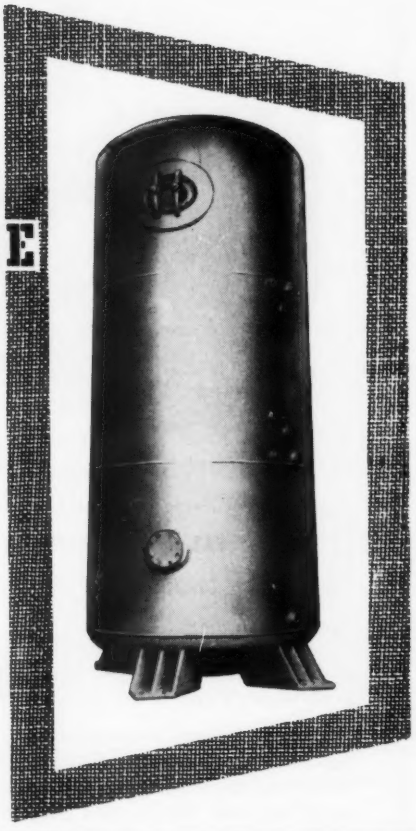
SOUTHBOROUGH GROUP

112-122 COOMBE LANE, LONDON, S.W.20

TELEPHONE : WIMbledon 6311

Tick **No 159** on reply card for further details

FABRICATION SERVICE



We specialise in fabricating horizontal or vertical air receivers to customers' specifications, and pride ourselves on the attention paid to constructional details which ensure trouble-free service for the finished product.

The vertical air receiver illustrated right was designed for a working pressure of 150-lbs. per sq. in.

W. G. ALLEN & SONS (TIPTON) LTD. P.O. BOX 4, TIPTON, STAFFS

TEL: TIPTON 1266

Typical examples of Allen's Fabrication Service: *Low Pressure Welded Piping for Exhaust Steam, Gases, Water, etc. Pipes and Ducts for Super Power Station Boiler Plant; Hoppers; Casings; Tanks; Flat Platework; Manipulated Platework of all kinds; Bed Plates and Frames for Machines, etc.*

PNEUMATIC WINCHES

This particular winch — claimed to be the largest of its type, with a lifting capacity of 3 tons — was designed for use at Berkeley Power Station, but this and the smaller sizes have many industrial applications.

Safe working load 3 tons
Lifting speed 50′ per min.
Air consump. 300 c.f.m.
Drum cap. 1000-ft. of ¾″diam. Wire Rope.

FOR EASE OF CONTROL — LIFT PNEUMATICALLY

W. & E. MOORE LTD. *(Lifting Equipment Specialists)*

13-31 POPLAR HIGH STREET, LONDON, E.14. . Telephones: EASt 2613-7; 4601-2

Tick **No 160** on reply card for further details

Tick **No 161** on reply card for further details

VALVE CHARACTERISTIC METER
Mk III

The AVO Valve Characteristic Meter Mark III offers the Electronic Engineer far more than is generally implied by the words "a valve tester."

This compact and most comprehensive Meter sets a new high standard for instruments of its type. It will quickly test any standard receiving or small transmitting valve on any of its normal characteristics under conditions corresponding to a wide range of D.C. electrode voltages.

A new method of measuring mutual conductance ensures that the instrument can deal adequately with modern valves of high slope and short grid-base such as are commonly used in many types of electronic equipment.

PROVIDES all necessary data to enable Ia/Va, Ia/Vg, Ia/Vs, etc. curves to be drawn.

MEASURES mutual conductance up to 30mA/V.

DETERMINES inter-electrode insulation with heater both hot and cold.

GIVES direct measurement of "gas" current.

TESTS rectifying and signal diodes under reservoir load conditions.

COVERS all normal heater voltage up to 117V.

CIRCUIT improvements provide accurate setting and discrimination of grid voltage over the full range to 100V. negative.

A relay protects the instrument against damage through overloading the H.T. circuits and also affords a high measure of protection to the valve under test.

List Price
£80

The instrument is fitted with a hinged fold-over lid which protects the valve holders when not in use.

A comprehensive Instruction Book and detailed Valve Data Manual are provided.

● ***Write for a copy of the AVO Catalogue of Electrical and Electronic Instruments.***

AVO LTD

AVOCET HOUSE · 92-96 VAUXHALL BRIDGE ROAD · LONDON · S.W.1.
Telephone: VICtoria 3404 (12 lines)

Manufacturers of: ELECTRICAL, ELECTRONIC & NUCLEONIC INSTRUMENTS DOUGLAS & MACADIE COIL WINDING MACHINES

Tick **No 162** on reply card for further details

UKAEA
ENQUIRIES INVITED

SMP

PRECISION ENGINEERS

Brief Particulars of Plant Installed.

Lathes
Capstan.
Screw Cutting.
Special Purpose.

Milling Machines
Plain.
Universal.
Vertical.
Special Purpose.

Drilling Machines
Radial.
Sensitive.
Multi Spindle.
Tapping.

Grinding Machines
Plain.
Universal.
Surface.
Internal

Boring Machines
Single Spindle.
Double Ended.

Broaching Machines

Auto Screw Machines
Single Spindle up to 2¾" dia.
Multi Spindle up to 2¾" dia.

Presses
Up to 100 ton.

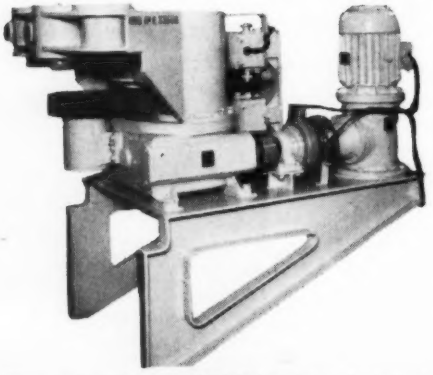
Stove Enamelling, Assembly, Linishing, Roto Finish, Plating, and Hardening Shops, Incl. H.F. Hardening. Toolroom, Experimental Department. Own Design and Drawing Office.

★ Approved A.I.D., D.I.Arm., A.R.B.

SCREW MACHINE PRODUCTS LTD.
Wooburn Green, Nr. High Wycombe, Bucks.
Telephone: Bourne End 111 & 101

Tick **No 163** on reply card for further details

SPECIAL GEAR UNITS



The illustration shows a SPECIAL drive designed and manufactured by us with the co-operation of the U.K.A.E.A. for use on the Dounreay Fast Breeder Experimental Reactor.

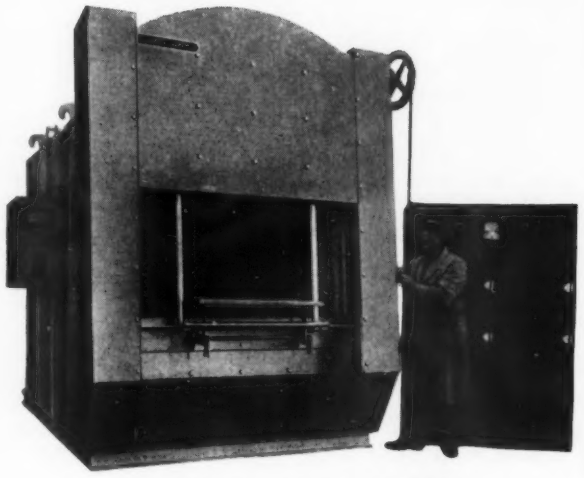
We welcome this kind of work on any gear and transmission problems as well as enquiries for our standard range of gear unit products and gears.

HIGEARS

HIGHFIELD GEAR & ENGINEERING CO. LTD.,
NILE STREET · HUDDERSFIELD · YORKSHIRE
Telephone: **Huddersfield 4490/1/2** *Telegrams:* **Higears**

Tick **No 164** on reply card for further details

A story to TELL!



A medium capacity heat-treatment furnace from the Barlow-Whitney range. Wide choice of standard models and, of course, custom-built units to order.

We mean a true story of course and one that if written fully would be far too long to read because it would cover a period of twenty-five years of intense activity, during which a wealth of experience and 'know-how' has been acquired about designing and building better equipment for all sorts of industrial heating applications for important concerns everywhere, and how this non-stop activity continues at an ever-increasing pace because today the name 'Barlow-Whitney' is the first choice, in the best circles, when it comes to—

Heat-treatment processing equipment of all kinds

OVENS AND FURNACES, VACUUM AND PRESSURE IMPREGNATION PLANTS, TROPICAL TESTING CHAMBERS, TINNING BATHS AND LEAD POTS, WAX AND COMPOUND KETTLES

and many other types of equipment, including of course

SPECIAL PROCESS PLANT TO MEET REQUIREMENTS

Write for further details quoting reference 16B

PROCESS HEATING Barlow-Whitney

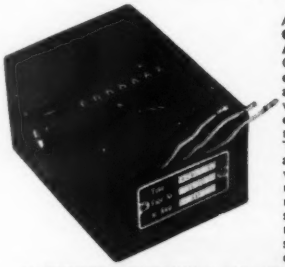
BARLOW-WHITNEY LTD., 2 Dorset Square, London, N.W.1 Tel: AMBassador 5485-6 Works, London & Bletchley

BWJ

Tick **No 165** on reply card for further details

ELMECO
ELECTRO-MAGNETIC IMPULSE
COUNTER
with a *NEW* type Stepping Motor

Panel Type



A new type of **Electro-Magnetic Impulse Counter**, manufactured by **Messrs. Elmeco, A.G.**, of **Zurich**, is now available in this Country. This Counter fills the gap between existing types of Electro-Magnetic Counter and the Electronic types; it can be supplied with **Mechanical, Electro-Magnetic,** or **combined Mechanical/Electro-Magnetic** resetting devices.
The **ELMECO** Counter has 5, 6 or 7 figures and is powered by a stepping motor from which the number drums are driven by a unique type of plastic belt. The result is a silent machine capable of accurate counting at a sustained rate of **30 impulses per second**; this can be increased to 50/60 impulses per second for limited periods, and the operating current is low.

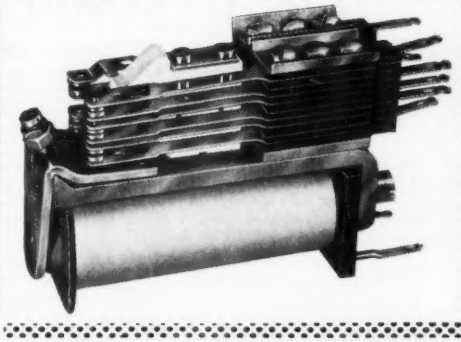
- **HIGHEST SELECTIVITY FOR IMPULSES**
- **LONGEST LIFE**
- **HIGHEST COUNTING RATE FOR CONTINUOUS OPERATION**
- **PRACTICALLY NOISELESS IN OPERATION**
- **ELASTIC DRIVE**
- **ACCOMPLISHED BY MOTOR DRIVE WITH PLASTIC BELT**

ELMECO

Write for particulars:
INGLIS KNIBB & COMPANY, 20-21 Tooks Court, Cursitor Street, London, E.C.4. Tel.: Holborn 2851

Tick **No 166** on reply card for further details

RELAYS
TO SPECIFICATION



POST OFFICE TYPE
3,000 and 600 RELAYS

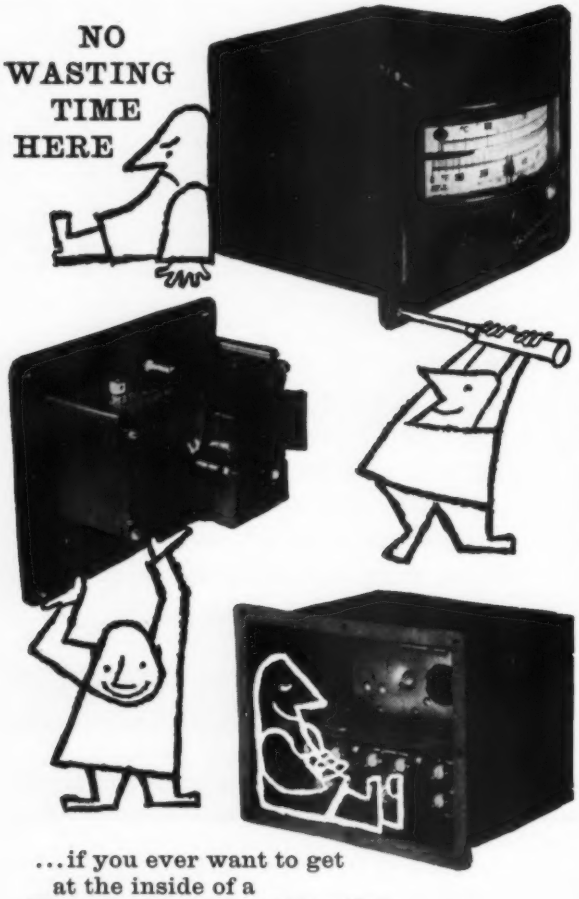
Specialists in tropical and Services jungle finish.
Guaranteed to full A.I.D. and I.E.M.E. standards.
Prompt Deliveries Prototypes within 24 hours.

Post Office approved. All relays guaranteed made in our own works.
P.T.F.E. insulation now available.

SIMMONDS

Manufacturers to H.M. Government Departments and leading Contractors
L. E. SIMMONDS LIMITED, 5 BYRON ROAD, HARROW, MIDDX.
TELEPHONE: HARROW 7797/9 TELEGRAMS: SIMRELAY HARROW

Tick **No 167** on reply card for further details



...if you ever want to get
at the inside of a
West Temperature Controller,
it opens from the front ...
comes out in sections ...

1,2,3..SIMPLE

West Instruments are models of simplicity. They've brought the principles of temperature control to a fine technical art ... stability allied to constant accuracy. Of course, West's specialise in temperature controllers; about the biggest sales in U.S.A.

What about after-sales service?

No wasting time there. Just as they do from all the major American and Continental cities, West's operate an organised system of regular calls throughout the country, to see that your temperature controller is always doing *precisely* what it was designed to do.

MODEL JP GARDSMAN

All components under-run for reliability. Corrects for thermal inertia, does not overshoot control points — unaffected by ambient temperatures — control unit simply unplugs for service or replacement.

WEST *Instrument* LIMITED

To: West Instruments Ltd., 52 Regent Street, Brighton 1
Please ask your area representative to let me have full details of the West Instrument Controllers.

NAME ..... POSITION .....

COMPANY .....

ADDRESS .....

NP/2

Tick **No 168** on reply card for further details

BARKER STEEL ROLLING DOORS WITH FLAT LATHS

Barker Steel Rolling Doors gain considerable strength from their flat lath design, the endlocks on alternate laths making the door secure and rigid. The flat laths are of steel, and are identical, replaceable or interchangeable in case of damage. They are rugged, neat — prime painted, sherardized or galvanised as required — and can be fitted to the widest openings.

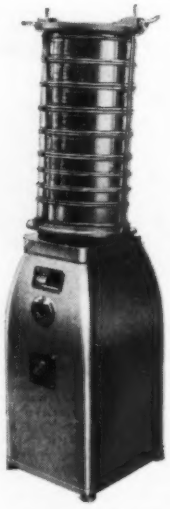
ALSO AVAILABLE WITH CONVENTIONAL CURVED LATHS

Write for fully informative literature to Dept. A7

JOHN BARKER & SONS (ENGINEERS) LTD.

Union Street, Ancoats, Manchester 4. Telephone: COLlyhurst 2018
London: Beacon Works, Strawberry Vale, Twickenham. Tel.: POPesgrove 0794
SCOTLAND: W. J. Leonard, 51 Braemar Place, Aberdeen

Tick **No 169** on reply card for further details



accurate particle size analysis

Simply vibrating or shaking test sieves by hand is not enough for an accurate sieve analysis of the particle size range of a material.

Vibration alone tends to aggregate rather than segregate particles, and shaking test sieves by hand is tedious and obviously inefficient.

The Inclyno Test Sieve Shaker, with a double movement that gyrates and jolts the test material around the entire surface area of the mesh of each test sieve, ensures perfect segregation of the various particle sizes in the shortest possible time.

The Inclyno Test Sieve Shaker is an essential unit for all laboratories and is standard equipment for sieve analyses in many government laboratories, nationalized industries and industry in general.

Operated by fractional h.p. motor and supplied complete with automatic time switch covering test periods up to 60 minutes. Three models available for all sizes of standard test sieves.

INCLYNO

TEST SIEVE SHAKER

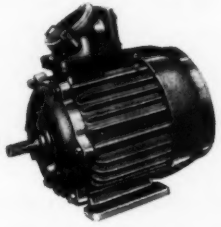
Write or telephone Crawley 25166 for List IN 3202

THE PASCALL ENGINEERING CO LTD
GATWICK ROAD · CRAWLEY · SUSSEX

Tick **No 170** on reply card for further details

No need for panic

No need to feel you are sitting on a powder barrel when you have EPE Flameproof electric motors—Buxton certified, of course. We have an enviable reputation for building reliable motors, standard or special, which are completely safe. And we build them at a price which will delight you. May we send you details?

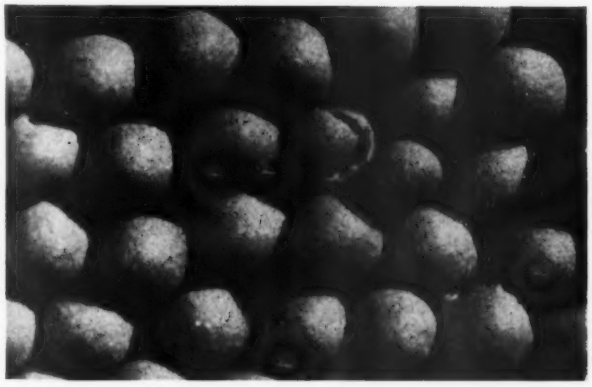


E·P·E

THE ELECTRICAL POWER ENGINEERING CO. (B'HAM) LTD.
Bromford Lane **Birmingham 8**
Telephone: STEchford 2261 **'Grams: Torque 'Phone Birmingham**
LONDON OFFICE: 421 Grand Buildings, Trafalgar Sq., London, W.C.2
Telephone: Whitehall 5643 & 7963

Tick **No 171** on reply card for further details

Are you sure . . .



that this picture shows a clutch of turtles' eggs? Maybe you're not too sure.*

But one thing you can be sure about—the Suffolk Iron Foundry has the answer to your welding problem.

Our team of highly-qualified technicians is always available. With their fleet of vans specially equipped with the latest oxy-acetylene apparatus they can solve any problem on the spot. All you have to do is ring Stowmarket 183.

* *(The "eggs" are really the heads of matches.)*

SUFFOLK IRON FOUNDRY (1920) LIMITED, STOWMARKET, SUFFOLK

Tick **No 172** on reply card for further details

STEEL FABRICATING AND MACHINING SPECIALISTS

LLOYD'S CLASS II FUSION WELDED VESSELS
CONTRACT GUILLOTINING—96" × ¼"
HYDRAULIC FORMING & BENDING—150 TONS
PLATE ROLLING—120" × ¼"
PROFILE CUTTING UP TO 6" THICK
ARC & GAS WELDING

●

MACHINING CAPACITY
UP TO 86" DIAMETER & 144" LENGTH

●

OIL, WATER & ACID STORAGE TANKS
Ex-Works & Fabricated on Site

●

EXPERIMENTAL & RESEARCH CHAMBERS
VACUUM VESSELS, PROCESSING & STORAGE
TANKS, DUCTING, PIPEWORK
CHIMNEYS, HANDLING EQUIPMENT
HEAT EXCHANGERS & STRUCTURES

●

Enquiries invited

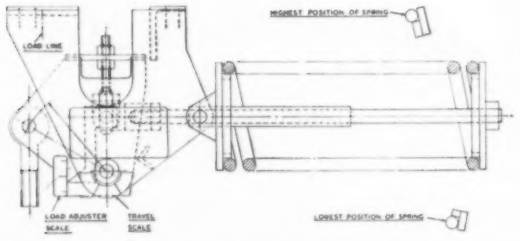
C.F.IDE ENGINEERING LTD.
EMPIRE WORKS
163 CLARENCE STREET
KINGSTON-UPON-THAMES
Phone Kingston 6820 & 6272

Tick **No 173** on reply card for further details

NOW...

'M' range Gensprings up to 80,000 lbs. and 12" travel ... only 2% deviation

Our new 'M' range of Constant Support Hangers is now available for loadings up to 80,000 lbs. and 12" travel—down to 2% deviation. More economical, both in application and first cost, and more compact than previous types, they provide increased travel with less headroom requirement. The 'M' Hangers have been developed from the 'W' range which have been chosen for Britain's first three commercial nuclear power stations.



At Bradwell, Berkeley, and Hunterston, Gensprings will provide safe, secure support of vital piping installations. The Constant and Variable Gensprings, together with the Sway Brace, provide a fully comprehensive range for all pipe support requirements and are, of course, widely used in conventional power stations, oil refineries, chemical plants, etc.

If you would like to know more about the new 'M' range, please send for full details.

Vokes Genspring

SUSPENSION SYSTEMS

VOKES GENSPRING LTD · GUILDFORD · SURREY

VG/24

Tick **No 174** on reply card for further details

Fabricated by

YARROW

... the bodies for twelve 60" Tansphere Valves being supplied by Hopkinsons Ltd for Bradwell-on-Sea Nuclear Power Station

YARROW & CO. LTD

SCOTSTOUN, GLASGOW, W4

SCOTLAND

Tick **No 175** on reply card for further details

TO INDICATE CONTROL OR RECORD

TEMPERATURE

For accuracy, ease of reading, robustness, economy and long, trouble free life install Rototherm Thermometers, Controllers and Recorders. Specialists in bi-metallic applications.

Write for details

Rototherm

BI-METAL MERCURY-IN-STEEL VAPOUR PRESSURE

THE BRITISH ROTOTHERM CO. LTD.

Merton Abbey, London, S.W.19 **LIBerty 7661**

Midland Factory: Hollis St., New Basford **Nottingham 77847**

Tick **No 176** on reply card for further details

W&J OIL FREE COMPRESSORS

DISPLACEMENT RANGE 1 to 136 c.f.m.

In the Food Processing, Brewing, Chemical and Paper Industries, also for pneumatic instrument control, it is essential that the air is free from oil in both droplet or vapour form. The W&J compressors use carbon rings and completely dry cylinders to achieve this purpose.

Manufactured now for several years they have proved themselves successful in many industries.

For further details please write requesting Leaflet Nos. 4, 20, and 28.

Illustrated is the twin cylinder model having a free air delivery of 50 c.f.m.

WILLIAMS & JAMES (ENGINEERS) LIMITED
GLOUCESTER · ENGLAND
TELEPHONE: GLOUCESTER 24021-2-3 · TELEGRAMS & CABLES: "COMPRESSOR GLOUCESTER"

Tick **No 177** on reply card for further details

ENDECOTTS TEST SIEVES

Inside Story

No Crevices to trap particles, frame and wire cloth are joined as one.

Guaranteed Accurate — Manufactured under licence from the British Standards Institution.

Mechanical Sieving is ideal with Endecotts Sieves—several simultaneous tests are possible with intermediate receiving pans.

British, U.S. Standards and Tyler Equivalents are readily available, many other international standards also supplied.

"ENDROCK" TEST SIEVE SHAKER

saves valuable time and effort of skilled personnel, similar to manual motion but is more consistent having a regular mechanical action—a time switch controls the length of time for tests.

We operate a **Recovering Service**—if sieving is important to your business, ring or write for literature —or for any advice you require—we'll be glad to help.

ENDECOTTS (FILTERS) LTD
Lombard Road · London, S.W.19
Telephone: LIBerty 8121/2 · Telegrams: ENDFILT, LONDON

Tick **No 178** on reply card for further details

THE DAVISON VACUMETER

A Mercury Column Vacuum Gauge for accurately registering the absolute pressure inside a Steam Condenser

★ Installed by The United Kingdom Atomic Energy Authority in Calder Hall.
★ In many Central Electricity Generating Board Stations and in others throughout the world.
★ Also in Turbine-driven Steamships.
★ Also makers of creep testing machines

DAVISON & CO. (HEXHAM) LTD.
(ENGINEERS)
HEXHAM-ON-TYNE **ENGLAND**
Telegrams: **"Davison, Hexham."** *Telephone:* **Hexham 7**

CLASSIFIED ADVERTISEMENTS

DISPLAY ANNOUNCEMENT RATES :— 1 insertion 40/- per single col. inch
6 insertions 38/- per single col. inch
12 insertions 36/- per single col. inch

LINEAGE ANNOUNCEMENT RATES :— 4/- per line. 5% discount 6 insertions, 10% discount 12 insertions

BOX Nos. :— 1/- extra will be charged

COPY DATE :— Advertisements for March issue to be received not later than February 17

SITUATIONS VACANT

INSTRUMENT ENGINEERING FOREMAN
for
CHAPELCROSS NUCLEAR POWER STATION

to be responsible to the Instrument Engineer for physical, electronic and nuclear instrumentation and control gear, including industrial television equipment.

A recognised engineering apprenticeship, or comparable training, and experience in physical, electronic or nuclear instrumentation and supervision of labour are essential. Knowledge of pulse techniques, radar, computer or data logging equipment and possession of an appropriate O.N.C., or equivalent, may be an advantage. Where necessary, training in nuclear reactor instrumentation will be given at another of the Authority's Works.

Salary £875
(at age 30 or over) to £1,050.
Contributory Superannuation.
Staff housing scheme.

Send postcard for application form, quoting reference 2891/J.28 to Works Secretary, UNITED KINGDOM ATOMIC ENERGY AUTHORITY, INDUSTRIAL GROUP, Chapelcross Works, Annan, Dumfriesshire, Scotland. CLOSING DATE: 23rd February, 1959.

ELECTRICAL PORCELAIN INSULATOR ENGINEER

for technical liaison and development. Degree or equivalent—preferably with experience on transmission, switchgear or transformers. Minimum starting salary £800 p.a. Excellent prospects.

Doulton Industrial Porcelains Limited
Ref. M.C.B.
Doulton House,
Albert Embankment, London, SE1

PROJECT ENGINEERS
ELECTRICAL ENGINEERS
ASSISTANT ENGINEERS
MATHEMATICIANS

Applications are invited for appointments in the

Special Engineering & Nuclear Division of John Brown & Co. Ltd.

The Division undertakes the engineering of special and nuclear projects applying and developing the experience and facilities of the Companies associated with John Brown & Co., Ltd. The range of work extends from heavy machinery and welded fabrications, pressure vessels, heat exchangers, pipe work, large valves, etc., to lightweight welded fabrications in alloy steels, mechanisms, control systems, instrumentation, etc.

PROJECT ENGINEERS should have an Honours degree in engineering or equivalent and have served an apprenticeship followed by not less than 3 years' experience in a senior capacity. He will lead a team of assistant engineers, designers and draughtsmen engaged on the project and detail design of plant and equipment.

ELECTRICAL ENGINEERS should have an Honours degree in engineering or equivalent and have served an apprenticeship followed by at least 3 years' industrial experience. The work will cover a wide variety of projects incorporating instrumentation, control and power services systems.

ASSISTANT ENGINEERS. Minimum qualifications will be a degree in engineering and/or graduate membership of their respective Institutions. They should have served a recognised apprenticeship and have had some design office experience. Successful applicants will be expected to attend specialist courses, serve periods with one or other of the Associated Companies and generally fit themselves for senior positions within the Division.

MATHEMATICIANS are required to carry out the performance calculations of control systems, fluid flow and heat transfer studies, stress analyses, etc. Experience of computer and simulator techniques would be an advantage.

All posts are permanent and pensionable and the salary will be according to qualifications and experience.

Replies which will be treated in confidence should give details of education, experience and training in chronological order, and be addressed to:—

THE CHIEF ENGINEER
SPECIAL ENGINEERING NUCLEAR DIVISION
JOHN BROWN & COMPANY LIMITED
20, EASTBOURNE TERRACE, LONDON, W.2.

PLESSEY NUCLEONICS LTD., NORTHAMPTON

LABORATORY TECHNICIAN

A Laboratory Technician with two to five years' experience on development of radiation detectors for the nuclear energy industry, should investigate an opportunity with this Company. We have a vacancy for which a knowledge of light engineering and general physics laboratory practice including high vacuum techniques, is desirable. Construction and evaluation of new types of detector, and the development of new techniques of construction are also involved. H.N.C. (Min.). Good working conditions. Canteen facilities. Pension Scheme. Salary will please successful applicant.

Write Personnel Dept. (L.T.),
Plessey Nucleonics Ltd.,
Weedon Road,
Northampton

A.E.I.–JOHN THOMPSON NUCLEAR ENERGY Co Ltd

Radbroke Hall, Knutsford

have vacancies for ELECTRICAL AND MECHANICAL ENGINEERS of Honours Degree standard, to work on design of experimental equipment.

Candidates should have served a recognized apprenticeship followed by some design experience. A knowledge of Electronics or Strength of Materials is desirable but not essential.

The offices are situated in Knutsford, and the Company provides transport from the Stretford/Sale/Altrincham areas. This position is on the permanent staff and there is a contributory pension scheme in operation.

Applications should be made in writing, giving details of age, experience and present salary (which will be treated in strict confidence), to the Chief Engineer, quoting ref.: DW/JO.

SITUATIONS VACANT

STRESS ANALYST

A vacancy exists in the Group Research Laboratories for a young UNIVERSITY GRADUATE.

The post covers a wide range of interesting aspects of this class of work, and, in addition to conventional design studies, would involve a large amount of design work directly associated with large Nuclear Power Station projects.

Design of unusual Pressure Vessels would be dealt with, and there would be scope for a certain amount of original investigatory work. The successful applicant would also be expected to act in an advisory capacity on stress problems when approached by member Companies of the Group.

Staff Pensions and a Sickness Insurance Scheme in operation. Sports and Social facilities.

Applicants are invited to write in confidence to the

Personnel Manager,
John Thompson Limited,
Wolverhampton
(Ref : PJP/-)

NUCLEAR POWER

Graduate Mechanical Engineer required for development work (London area) connected with pressurized-water nuclear reactor system components and other high-pressure plant.

Applicants should have served an apprenticeship and have some industrial experience in the field of high-pressure steam-raising plant.

Please apply in writing, stating age, qualifications and experience, to Staff Manager,

Foster Wheeler Ltd,
3 Ixworth Place,
London, SW3

CONSULTING ENGINEERS NUCLEAR POWER DEPT

Require young ELECTRICAL ENGINEER in LONDON OFFICE for work on control and instrumentation of Nuclear Power reactors. Good degree and practical experience in light current of instrument engineering desirable. Write:—

Kennedy & Donkin
(H.J.P./27),
12 Caxton Street,
London, SW1

SITUATIONS VACANT

PLESSEY NUCLEONICS NORTHAMPTON PHYSICISTS

Physicists with a degree in their subject, and tempered with two to five years' experience in research and development work are sought by this Company. They would be members of a laboratory team engaged in the application of the techniques of nuclear physics to a wide range of problems, and in research on a number of interesting projects involving the use of scintillation counters of various types. Salaries genuinely related to worth, ability and potential recognized. The special opportunities for advancement in this field are well known, our particular conditions are good and in the first flight of springboards. Applications to Personnel Department,

Plessey Nucleonics Ltd.,
Weedon Road,
Northampton

COURSES

U.K.A.E.A. HARWELL REACTOR SCHOOL

Control and Instrumentation of Reactors

The second course on 'The Control and Instrumentation of Reactors' will be held at the Harwell Reactor School from 7th to 17th July, 1959, inclusive. The fee for the course will be 50 guineas exclusive of accommodation.
Application forms and further details can be had from :—

The Principal,
Reactor School,
Atomic Energy Research Establishment,
Harwell, Didcot,
Berkshire

AUTOMATION

Authoritative courses are now available in Digital and Analogue Computor Technology, Applied Electronics, Data Processing and Instrumentation up to professional level by home study. Individual enrolment or industrial group scheme enrolments accepted. Syllabuses and prospectus sent on request. British Institute of Engineering Technology (Dept. No. 4), College House, Kensington, W.8.

COURSES (*contd.*)

U.K.A.E.A. HARWELL REACTOR SCHOOL

Senior Technical Executives' Course

The next Course on which places are available will be held from 15th to 25th June, 1959, inclusive.

The fee for the course is 50 guineas exclusive of accommodation.

Application forms and further details can be had from :—

The Principal,
Reactor School,
Atomic Energy Research Establishment,
Harwell, Didcot,
Berkshire

CAPACITY AVAILABLE

ALPHAMIN LIMITED.—A complete design and fabrication service available for all types of aluminium and steel fabrication including welding by Argon-arc process. We have considerable design experience and would welcome your enquiries. 4 Dunston Street, Kingsland Road, London, E.8. Phone CLIssold 4161.

ELECTROPOLISHING—specialists in electro-polishing of all sizes of stainless steel fabrications at greatly reduced cost compared with mechanical polishing. **Fully approved for Atomic Energy work.** Electropol Processing Ltd., Trading Estate, Farnham, Surrey.

METAL SPINNINGS to requirements. A.I.D approved. Martin-Golod Ltd, Maybury Gardens, NW10. WILlesden 3888.

DESIGN TEAMS AVAILABLE for plant and mechanical engineering projects in the nuclear field. Norris Brothers Ltd, 53 Victoria Street, London, SW1. Phone: Abbey 6132.

MODELS

MODELS for planning
MODELS for prestige
MODELS for instruction
MODELS for experimenting

MODELS can save wear and tear amongst personnel and thousands of pounds worth of time and material.

MODELS can be an invaluable aid to sales staff.

RICHARD DENDY & ASSOCIATES of 4, 5 & 6 Seaton Place, Hampstead Road, London N.W.1. EUSton 7617 are makers of fine MODELS and invite your enquiries.

BUSINESS OPPORTUNITIES

ENGINEERING ORGANIZATION with established connexions in the nuclear field seek to extend the range of products handled. Manufacturers who feel that an extension of their sales effort in this field would be advantageous are invited to write to: Box No. NP202.

ADVERTISERS IN THIS ISSUE

Abingdon King Dick Ltd 129
ACF Industries Inc 43
Advance Components Ltd 30
Airmec Ltd 26
Allen & Sons (Tipton) Ltd, W. G. 135
Armstrong Whitworth Aircraft Ltd, Sir W. G. 118
Armstrong Siddeley Motors 12
Associated Lead Mfrs Ltd 131
Atlas Steel Foundry & Eng Co Ltd, The 131
Avo Ltd 136
Ayling Nuclear Equipment Co 7

Bailey Meters & Controls Ltd 16
Barker & Sons (Engineers) Ltd, John 138
Barlow-Whitney Ltd 137
Birmetals Ltd 52
Blackwell's 113
Bramah & Co Ltd, J. R. 132
British Acheson Electrodes Ltd 115
British Rototherm Co Ltd, The 140
Butterworth's Scientific Publications 112

Cambridge University Press 113
Cape Asbestos Co Ltd, The 45
Clay Cross (Iron & Foundries) Ltd 40
Cox & Danks Ltd 53

Darham Industries (London) Ltd 130
Darlington Insulation Co Ltd, The 50
Davison & Co (Hexham) Ltd 141
DP Battery Co Ltd, The 24
Dynatron Radio Ltd 121

Edwards High Vacuum Ltd 116
Electrical Power Eng Co (B'ham) Ltd, The 139
Electronic Associates Inc 44
Electrothermal Eng Ltd 133
EMB Co Ltd, The 119
Endecotts (Filters) Ltd 141
Energia Nucleare 125
Engineering, Marine, Welding and Nuclear Energy Exhibition 55
Erhard, Johannes 18
Evers, D. H. 127
Evode Paints Div 10

Fraser & Fraser Ltd 134

General Electric Co Ltd, The 41
Graviner Ltd 120
Grazebrook Ltd, M. & W. 134

Harland Eng Co Ltd, The 117
Harvey & Co. (London) Ltd, G. A. 20
Highfield Gear & Eng Co Ltd 136
High Voltage Eng Corp 95
Holman Bros Ltd Cover 4

Ide Eng Co, C. F. 139
Imhof Ltd, Alfred 36
Imperial Chemical Industries Ltd (Metals div) 56
Imperial Chemical Industries Ltd 31
Inglis Knibb & Co 137

KDG Instruments Ltd 122
Kennedy & Co Ltd, Allan 19
Kirk & Co (Tubes) Ltd 131

Lincoln Electric Co Ltd 46
Londex Ltd 128
Lyons Ltd, Claude 132

Mallinson & Sons Ltd, William 121
Mancuna Eng Ltd 111
Marston Excelsior Ltd 48
Metal & Pipeline Endurance Ltd 130
Mirrlees, Bickerton & Day Ltd 42
Mollart Engineering Co Ltd 22
Moore, Ltd, W. & E. 135
Mulberry Co, The 118
Murex Ltd 120

Newalls Insulation Co Ltd 35
Nobrac Carbon Ltd 126
Norwood Steel Equipment Ltd 103
Nuclear Power Binder 125
Nuclear Reactor Physics 128

Pascall Eng Co Ltd, The 138
Paterson Hughes Eng Co Ltd 37
Photostat Ltd 116
Powell Duffryn Carbon Prods Ltd 2
Premier Precision Ltd 105
Pyrotenex Ltd 28

Ransome & Marles Bearing Co Ltd 4, 9
Rawlplug Co Ltd, The 25
Research & Control Instruments Ltd 3

Sangamo Weston Ltd 51
Savage & Parsons Ltd Cover 2
Screw Machine Products Ltd 136
Serck Radiators Ltd 11
Serck Tubes Ltd 11
Shell Chemical Co Ltd 47
Shell Mex & BP Ltd 100, 101
Simmonds Ltd, L. E. 137
Simon-Carves Ltd 17
Simplifix Couplings Ltd 126
Smith & Sons (Clerkenwell) Ltd, J. 133
Solartron Electronic Group Ltd, The 58, 97
Southborough Group 134
Stainless Steel Profile Cutters Ltd 144
Stanton Ironworks Co Ltd, The Cover 3
Steel, Peech & Tozer 54
Stream-Line Filters Ltd 114
Suffolk Iron Foundry (1920) Ltd 139
Sunvic Controls Ltd 29
Superheater Co Ltd, The 49

Teddington Aircraft Controls Ltd 6
Techniques Nucléaires 122
Thermal Syndicate Ltd, The 114

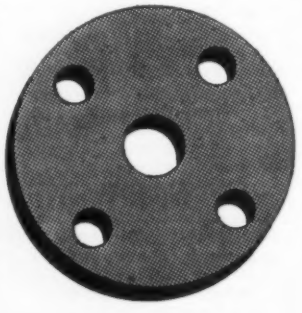
Universal Boilers & Eng Co Ltd 5

Versil Ltd 38, 39
Vokes Genspring Ltd 140
Vokes Ltd 27

Wakefield Dick Industrial Oils Ltd 107
Walker Ltd, C. & W. 129
West Instrument Ltd 138
Weston & Co Ltd, Charles 23
Westool Ltd 14, 15
Wharton Crane & Hoist Co Ltd 32
Whipp & Bourne Ltd 4
Wiggin & Co Ltd, Henry 109
Williams & James (Engineers) Ltd 141
Worthington-Simpson Ltd 13

Yarrow & Co Ltd 140

Tick **No 179** on reply card for further details



STAINLESS TUBES & FLANGES

We offer in approved grades of Stainless Steel

★ FLANGES MACHINED TO B.S. TABLES OR TO SPECIAL SIZES
★ SOLID DRAWN TUBES—FABRICATED PIPES
★ ROUND and HEXAGON BAR
★ PROFILES CUT TO ANY THICKNESS OR SIZE
★ CASTINGS TO CUSTOMERS SPECIFICATION

Keen Prices — Prompt Delivery

Send enquiries to Dept. N.P.

STAINLESS STEEL PROFILE CUTTERS LTD.

Farfac Works, Kings Grove, MAIDENHEAD. *'phone* 1522/23.

Tick No 183 on reply card for further details

STANTON

PIPES ARE USED IN NUCLEAR AND CONVENTIONAL POWER STATIONS AND IN OIL REFINERIES THROUGHOUT THE WORLD

SPUN IRON PIPES
for water, gas or sewage

SPUN CONCRETE PIPES
for circulating water & drainage

PRESTRESSED CONCRETE PRESSURE PIPES
for water services

FLANGED SPUN IRON PIPES
for oil handling

THICK WALL SPUN IRON PIPES
for ash & dust disposal mains

THE LARGEST CAST IRON & CONCRETE PIPE MANUFACTURERS IN GREAT BRITAIN

THE STANTON IRONWORKS COMPANY LIMITED NEAR NOTTINGHAM ENGLAND

Tick **No 184** on reply card for further details

Holman two-stage compression gives constant high output from sea level to 5,000 feet

High output from low power—that is the first feature of all Holman two-stage portable compressors. And they are tested by B.C.A.S. standards to give guaranteed constant performance at altitude.

Holman 'two-staging' gives you even more; lower temperatures and less oil consumption, negligible carbon deposits, less friction, stress, and wear on valves. So Holman compressors cut running cost—the *real* cost of all pneumatic equipment. It's wise budgeting to order a Holman; you will have the most efficient and reliable compressor there is.

Holman
PNEUMATIC EQUIPMENT

PAYS . . . WITH ITS LIFE

THE HOLMAN GROUP

HOLMAN BROS. LIMITED, CAMBORNE, ENGLAND
A company in the Holman Group which has branches, technical representatives and agents throughout the United Kingdom and the world.
Telephone: Camborne 2275 (10 lines). Telegrams: Airdrill, Telex, Camborne. London Office: 44 Brook Street, W.1. Telephone. HYDe Park 9444

HK4